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NOTES ON
Sanitary Appliances

WAR PLANS DIVISION
APRIL, 1919

War Department : Document No. 897
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WAR DEPARTMENT,
WASHINGTON, *March 20, 1919.*

The report of the laboratories of field sanitation at Fort Riley, Kans., and Camp Greenleaf, Ga., by Lieut. Col. Charles S. Williamson, M. C., director, is published for the information and guidance of all concerned.

[062.1 A. G. O.]

BY ORDER OF THE SECRETARY OF WAR:

FRANK McINTYRE,
Major General, Acting Chief of Staff.

OFFICIAL:
P. C. HARRIS,
The Adjutant General.

463292

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FOREWORD.

The purpose of this report is to place in the hands of the medical officers of the service the results of our experience in the construction and operation of a large number of sanitary appliances in the laboratories of field sanitation at Fort Riley and Camp Greenleaf. It has been the primary aim of these laboratories to do, as far as was possible with their equipment, real research work, comparable with that done in any other laboratory. Out of this work has come a number of new appliances, some of which, we venture to hope, may prove worthy of a permanent place in the sanitary armamentarium. We have especially endeavored to try out these appliances under every conceivable condition and subject them to a rigid critique. While in all some 114 appliances were built and studied, some of these possess only historical interest, others have a very limited field of utility and yet are valuable in their place, and still others, we believe, have sufficient real merit to warrant their being brought to the attention of the medical officer. We have, therefore, given in considerable detail the construction notes and our experiences with those which are either original or, if not original, especially valuable. There are probably few, if any, places where better opportunities have been had for making a comparative study of these various appliances and methods under identical conditions than in these two laboratories, and it is hoped that means may be provided for continuing the research work done here under better conditions and in more experienced hands. A large number of requests for blue prints have been received from officers desiring information along these lines, and it is hoped that this little pamphlet will in some measure fill this want.

CHARLES SPENCER WILLIAMSON,
Lieutenant Colonel, Medical Corps, Director.

NOTES ON SANITARY APPLIANCES.

ORIGINAL APPLIANCES.

MULTIPLE SHELF INCINERATOR.

FIXED TYPE.

Designed by Lieut. Col. Charles Spencer Williamson.

The observations which led to the development of this design were the following: At the Fort Riley laboratory of sanitation a large number of the usual types of incinerators which have been used, both in the American and British services, had been constructed and tried out as to practicability, capacity, and fuel consumption in a thorough and painstaking way. After some six months of constant experimentation it became perfectly evident that none of them possessed any claims to be more than the crudest sort of device, and that all of them were extraordinarily extravagant of fuel. Inquiry was then instituted into the amounts of fuel which were being used in burning garbage in various places, and the writer was astonished to find that in a great majority the amount of fuel actually burned exceeded the amount of garbage burned, and in many places in the proportion of 2 to 1. Since the ordinary division, even under war-time conditions of economy, produces 9 or 10 tons of garbage daily, it will be seen that the fuel required to consume this in company incinerators will of itself cost as much money in a few days as would suffice to build this incinerator. One had only to see 15 or 18 incinerators of different types, all operating at the same time, under identical conditions, to realize that the great majority of the heat was being used to heat the atmosphere rather than to burn the garbage, and that here was a fertile field for work, and so we set ourselves the task of devising an incinerator.

About this time a casual remark of Surg. Gen. Gorgas, at the time of an inspection of the laboratory, to the effect that what was needed was "a fireless incinerator," set us to thinking still further as to whether such a thing was possible. It required a relatively short study of the available data on garbage to make it clear that ordinary mixed garbage, drained of its water, but otherwise just as it comes from the kitchens in our cantonments, contains enough heat units to insure its own combustion. Starting with this as a basis, the multiple shelf incinerator gradually took shape in our mind. It would not be profitable to enumerate the different structural changes which were made in the development of the design as we now have it, except to say that we have experimented with a varying number of

shelves, with varying degrees of overlap, with varying kinds of material for the shelves, with both horizontal and obliquely placed shelves, and with different types of grates, etc. In short, we have experimented in almost every possible direction which still admitted of the necessary simplicity of design.

The description of the apparatus which is here given is substantially identical with that given in the Military Surgeon for July, 1918, the article being written in April of the same year. Since that time we had abundant opportunity for further experimentation during the following four months at Fort Riley. The writer was then ordered to Camp Greenleaf as director of the laboratory at that place, and has had the opportunity of building two more of these incinerators, thus gaining additional experience in their construction and management. This further experience has led to no important change. A few minor details have been improved upon, and increased experience with the apparatus has only confirmed our previous confidence in it. It is believed that in this incinerator a satisfactory solution has been found for the easy, cheap, and simple disposal of the garbage of our cantonments, since it is easily built and truly "fireless," since it requires, after the initial charge, absolutely no fuel of any kind whatsoever, provided it be kept in constant operation.

The incinerator consists essentially of a rectangular brick chimney 4½ by 6 feet inside diameter, with a grate, and above this grate a series of six drying shelves arranged in zigzag fashion, as baffle plates, and overlapping each other in such a way that they close off the entire cross section of the chimney, excepting for a slit 1 foot wide along the longer side. This arrangement, as will be seen at a glance from the side elevation, has the effect of causing the heat to be deflected alternately from front to rear.

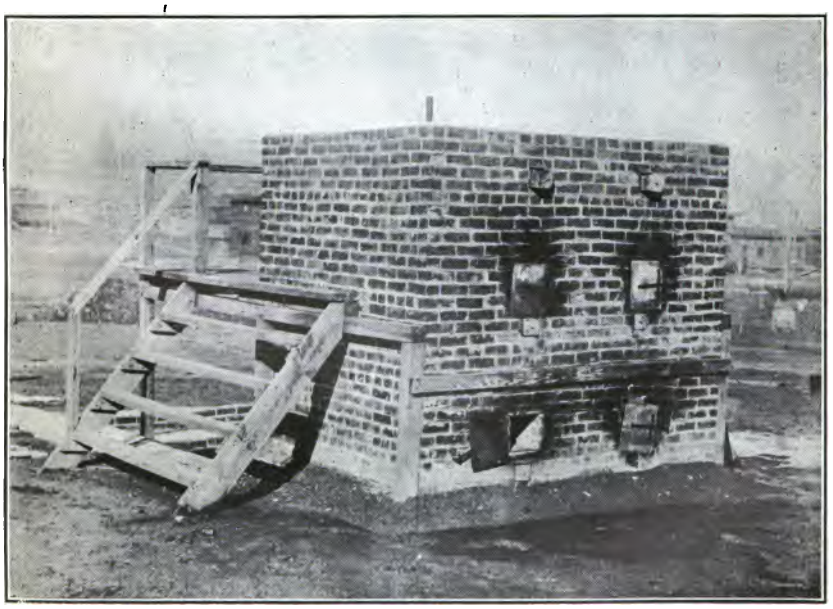
We have experimented with various numbers of shelves, but for an apparatus of this size six is found to be the best, since when properly operated but litle heat is wasted, yet the apparatus is kept within reasonable bounds of simplicity. The garbage is thrown in at the top of the stack, which is 12 feet high, and then pushed down from one shelf to the next lower one by a long-handled hoe or rake, which is inserted into the stack through the two small doors just above each shelf. In this way it is thoroughly and yet gradually dried until when it reaches the lower shelf it is practically ready for combustion. After a short stay on this lower shelf it begins to take fire, at which point it is pushed off the lowest shelf, which extends only to the middle of the stack, on to the fire on the grate bars below, where it promptly takes fire. From this point on no further wood is used, since the burning garbage furnishes much more than sufficient heat to incinerate itself.

The apparatus is started by loading all the shelves with a thin layer of garbage, not to exceed 2 or 3 inches in depth, building a fire under the lowest shelf, which is continued until the garbage on this shelf begins to catch fire, when it is pushed into the flames and the fuel consumption is then at an end.

It should be emphasized that all of the fuel to be used should be put on at the very beginning, and it should be of a quickly inflammable nature. We have used old boxes, odd pieces of 2 by 4's and

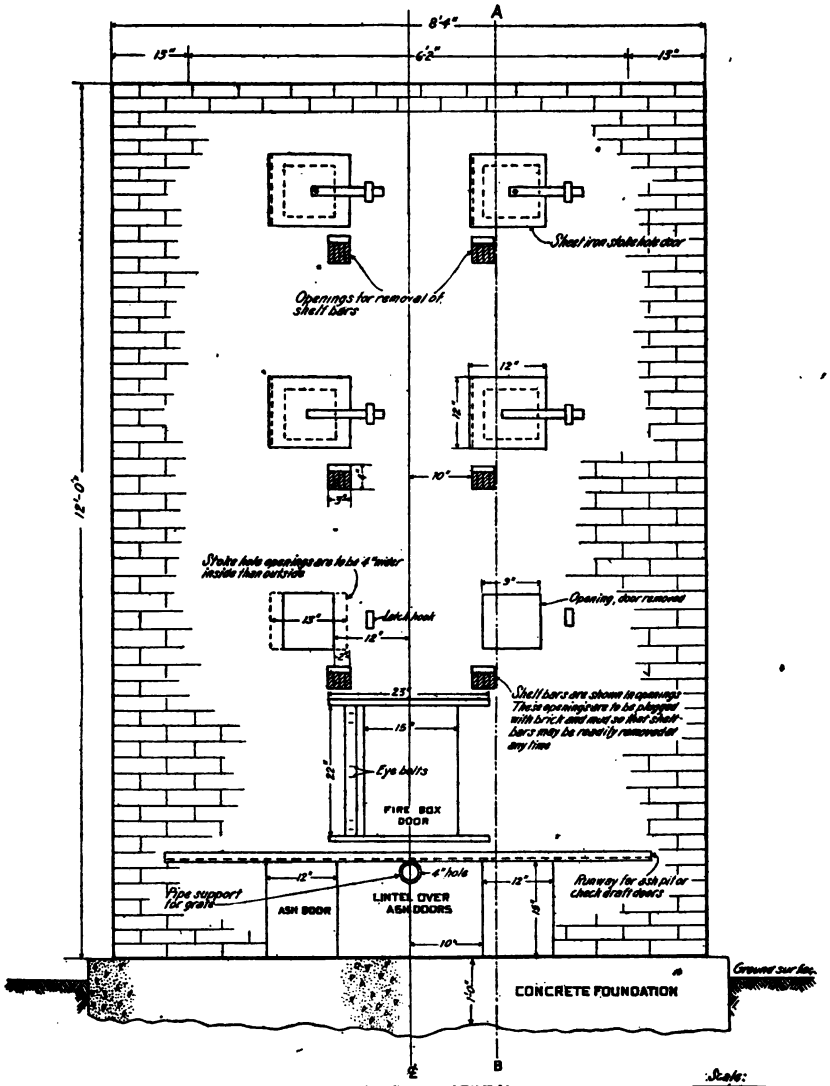
MULTIPLE SHELF INCINERATOR, SIZE SUITABLE FOR DIVISION OR CANTONMENT.

Front view.



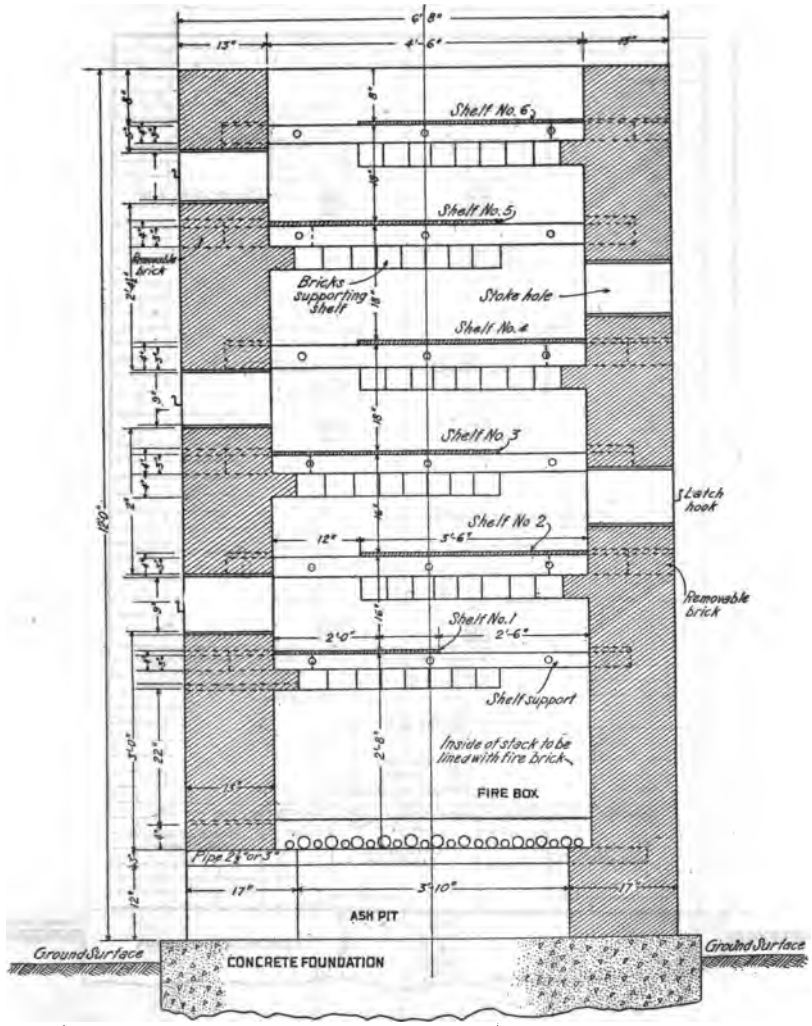
MULTIPLE SHELF INCINERATOR, SIZE SUITABLE FOR DIVISION OR CANTONMENT.

Note.—In this view the blocks provided to close the openings for shelf bars are showr partly projecting.



FRONT ELEVATION

MULTIPLE SHELF INCINERATOR



SECTIONAL ELEVATION ON LINE A-B

MULTIPLE SHELF INCINERATOR

split cordwood. Two hundred pounds is the smallest amount with which we have been able to start the apparatus with a satisfactory degree of speed. While it doubtless could be done with 50 pounds less fuel, it is not worth while to make the attempt unless the scarcity of fuel is really acute. While the operation of the apparatus is simplicity itself when once seen, there are several points which need emphasis. One is that the garbage on the lowest shelf should never be pushed down onto the grate bars until it commences to take fire, because if this is done the fire will certainly be smothered. In starting the operation it is important to acquire a bed of hot coals, so that the garbage will catch fire almost instantly upon reaching the grate bars. As fast as each shelf is emptied the material on the next higher shelf is pushed down upon it and more garbage put in at the top. For convenience the stack is provided with a wooden platform and two pairs of steps, which aid in loading and in tending the upper shelves.

Inasmuch as the volume of the garbage is greatly diminished by the evaporation of the water, a layer 4 inches thick on the top shelf will scarcely cover 1 inch by the time it reaches the first shelf. The immense amount of water evaporated is readily seen by the amount of steam which is given off at the top of the stack. It is convenient to build the stack in a small hill, as shown in the picture.

In all the times we have operated the apparatus the garbage has never failed to consume itself after the initial charge of wood. A point of considerable importance is that no rain which we have ever encountered exerts any appreciable effect upon the proper functionating of the apparatus, nor do high winds effect it materially, although the latter make it disagreeable for the man operating the top shelf. This may be readily obviated by setting up a thin piece of sheet iron to ward off the smoke.

The only difficulties which we have met and which we feel that we have now overcome have been to find materials capable of withstanding the intense heat and yet which were readily obtainable under the ordinary conditions of warfare. We have held many consultations with engineers of recognized ability, but found that even they were able to form but a very imperfect idea of the great heat generated by the combustion of the garbage. On being assured that cast-iron grate bars, used as supports for the shelves, would certainly withstand a very much greater heat than a little homemade furnace of this sort could possibly produce, we obtained a half dozen pairs of these and found that they did not even survive one trial. Iron pipe, while much better than cast-iron bars, is still not strong enough for this larger model.

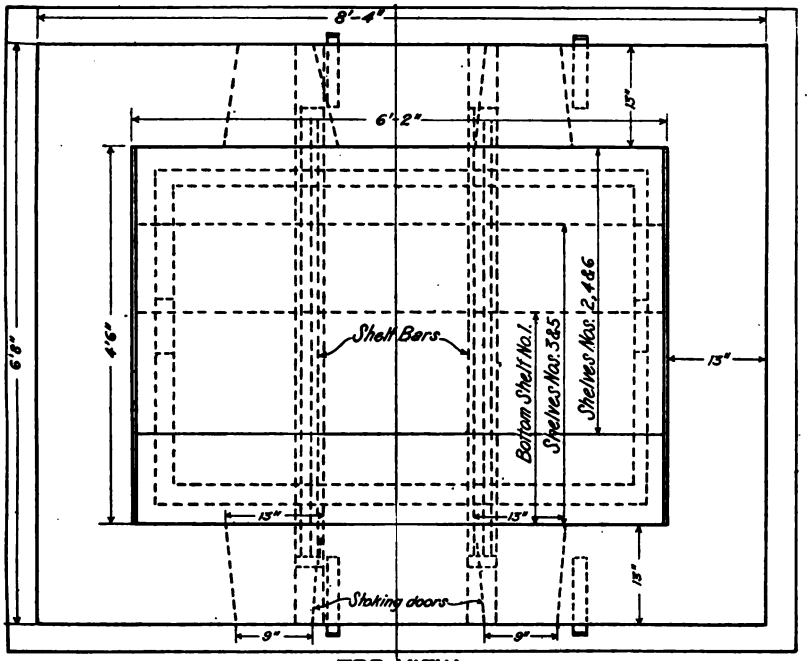
We finally adopted wrought iron or steel wagon tires. The melting point of wrought iron is much above that of cast iron and it retains its strength quite satisfactorily at a cherry red heat. The shelf supports in the apparatus we have were made by taking wagon tires, straightening them, cutting them to the proper length, placing from three to six of them side by side, with a thin washer between and bolting them together at three or four points. A composite bar of this sort will, even when heated to a fairly bright red, stand up very well under the weights which it is called upon to support. Inasmuch as one of the bars may be taken out and replaced in perhaps three

minutes, without removing the shelf which it supports, by simply lifting up the shelf by hand or with a lever and, since it can be replaced in an inverted position, it is a matter of no consequence if, because of the fire getting too hot, one of the supports should sag a little, since this replacing it upside down will cause it to resume its original form in the event of its sagging a second time. A good deal of experimentation leads us to prefer boiler plates of a thickness of one-quarter or five-sixteenths of an inch, since this will stand up very well without more than an inappreciable degree of buckling and may be taken out very readily and straightened with a sledge hammer in a half hour's time.

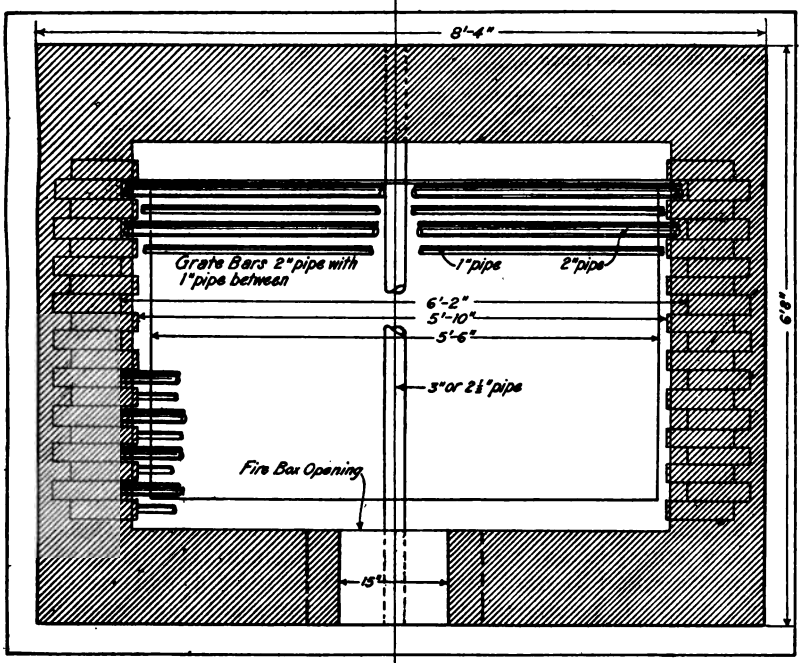
There is another advantage in not having the shelves too heavy, namely, that they are readily obtainable without being specially made. The shelves in our original apparatus were made of one-quarter inch boiler plate which came from an old tank which had been used for years by a railroad and then discarded as scrap. These plates were straightened with a sledge, cut and used as shelves. The actual thickness was less than three-sixteenths of an inch and they were badly corroded. The grate bars are, like the shelves and shelf supports, readily removable, since they are merely laid on a brick ledge and separated from each other by bricks laid on edge.

Certain points in construction should be noted. In order that the shelves may be easily removed, they are merely laid on the supports and not fastened in any way. At least an inch should be allowed for expansion. On three sides the shelves are supported by bricks imbedded in the walls and, in addition to these, two of the iron shelf supports already referred to support the shelves at the third point. These shelf supports are not fastened in any way, but one end rests in a blind recess in the wall and the opposite end in a narrow slit-like opening left in the wall about the size of a brick placed on edge. This opening is merely closed by a loose brick imbedded in clay, so that it may be knocked out without disturbing the integrity of the wall. A concrete block is excellent. To prevent the weight of the shelf supports from breaking the brick it is desirable to place a plate of iron under each slit. For this purpose a tie plate, such as can be found around any railroad, is very satisfactory. The fire door is made of two layers of thin sheet iron with asbestos in between. It may, of course, be made of heavy iron, but this is not necessary. We have found the best method of securing it is by taking two strips of wagon tire and bolting these through the wall by means of three eye-bolts, which can be made in a few minutes by any blacksmith. These three eyebolts make a satisfactory hinge.

In the construction of the stack the entire lining should be of good quality fire brick, since ordinary brick will not withstand the intense heat for any great length of time if the incinerator be kept in operation. It should be again emphasized that, when properly constructed, this incinerator leaves little to be wished for as a means of disposal of solid garbage, and the only difficulty we have met is that of keeping the fire from running away. It is for this reason that we use check-draft doors, so that when the first tinge of red color is seen in the plates the draft can be checked down to prevent the shelves and supports getting too hot. It is evident that the greatest heat will be on the two or three lower shelves, and for these shelves we make the



TOP VIEW

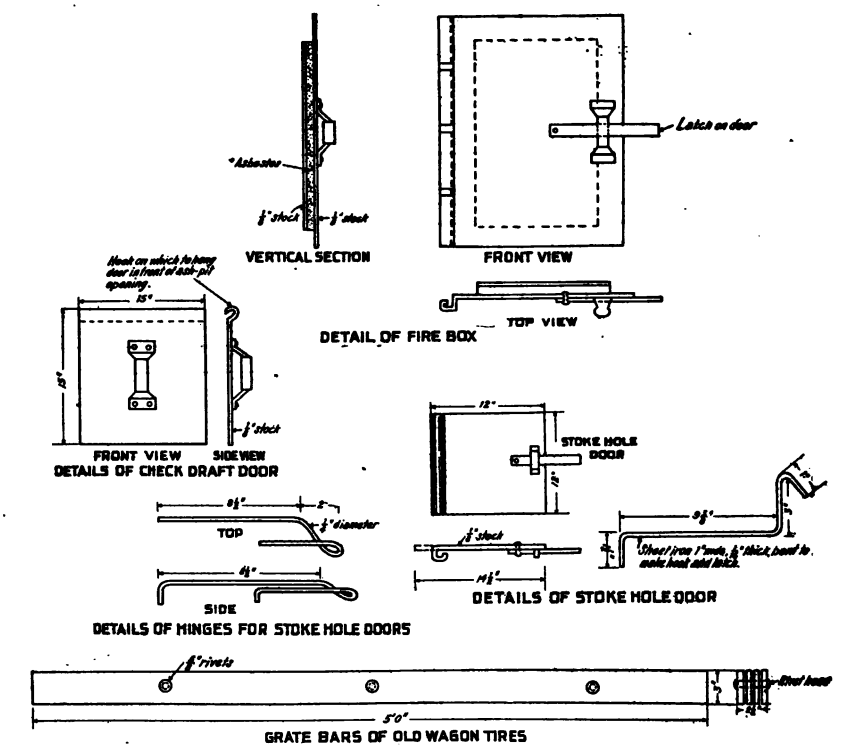


SECTIONAL PLAN SHOWING GRATE

MULTIPLE SHELF INCINERATOR

Scale: 0 3" 6" 9" 12"

12-A



DETAILS OF APPURTENANCES
MULTIPLE SHELF INCINERATOR

supports at least twice as strong as for the upper ones. Practically what we have done is to bolt together as many tires, with a thin washer between, as we can squeeze through the opening left by the brick removed.

The capacity of this incinerator depends, of course, upon the kind of garbage, but to a very much greater extent upon the temperature at which the apparatus is worked. In regard to the first of these points our remarks apply to mixed garbage as produced in our cantonments, and the quality of this does not change very greatly at different times. In regard to the second point too much stress can not be laid upon this. The apparatus is designed and constructed with a view to making the shelves of a heat-conducting material, not of fire-clay or fire-brick arches. The golden rule in operating this incinerator is "under no circumstances let either of the two lower shelves, which are, of course, the hottest, ever show more than a faint suspicion of red." If this rule is not observed and the plates allowed to acquire a bright red color, which may very readily happen, after it has been run six or eight hours, with perhaps 8 or 10 tons of garbage, the plates will sag more or less and may have to be taken out the next day and straightened. While this can be done in an hours' time, it is unnecessary, injures the plates, and shows faulty management. The plates which we have now in the apparatus at Camp Greenleaf were brought from Riley and are the same ones used in our original apparatus and are still serviceable.

It is very evident, from the fact that the apparatus is absolutely self-supporting after the initial charge of fuel, that the economical way to run it is to keep it in continuous operation. We would, therefore, strongly urge that if this apparatus be used for, let us say, a division or an army cantonment producing 15,000 or 20,000 pounds of garbage per day, this weight being reckoned after draining off the water, that the burning of this amount be extended over the 24 hours, since in this way fewer men are required, the apparatus is not subjected to the risk of being overheated, and, above all, no fuel is used after it is once in operation. For example, in burning 9 or 10 tons of garbage daily, it will be better to carry on the operation at a rate which will require 24 hours to finish the combustion and then to start with the new day's supply. The writer believes this apparatus adequate to take care of the garbage of a division and even more, if run through the entire 24 hours. Through the courtesy of the reclamation officer at Camp Funston, Lieut. Larrieu, we have had the garbage at Camp Funston, with the remount station and the various civilian organizations, being all the organizations at this camp, with the exception of one detention camp, accurately weighed. The date chosen was Easter Sunday, since on a holiday of this sort the garbage is usually at its maximum. The amount for the 24 hours was 18,023 pounds, so that this apparatus has in less than 12 hours actually consumed more than the amount of garbage produced at Camp Funston. Since the entire cost of the apparatus is so small as to be negligible, where a division is concerned, it would be advisable to have two, the second one to be used in the event of a breakdown, although since the brickwork is very unlikely to be damaged, it is a very simple matter to have extra shelf supports and shelves at hand, and it is a matter of

not more than a half hour to remove all the shelves and another half hour sufficies to replace them.

In view of the very surprising results attained by this apparatus, a board was appointed by the then commandant of Fort Riley, Col. William N. Bispham, consisting of six officers, one being an engineer of experience in such matters, and this board made an official investigation of the apparatus and reported upon it. The following conclusions are taken verbatim from this report:

The board finds that this incinerator, as designed by Maj. C. S. Williamson, M. R. C., fulfills all the claims of this officer. It is the opinion of the board that the "multiple shelf incinerator" has the following advantages:

1. The construction of this apparatus is simple and its cost nominal.
2. The extremely small amount of wood required to incinerate a relatively large amount of garbage (200 pounds for 19,023 pounds, as tested), and consequently a relative small cost of operation. As regards this point, attention is invited to the fact that the dessicated garbage is used as the fuel for the subsequent incineration of other garbage and the apparatus is designed with this idea in view.
3. A relatively small number of men required to operate the apparatus, which required only six men during the test made by the board.

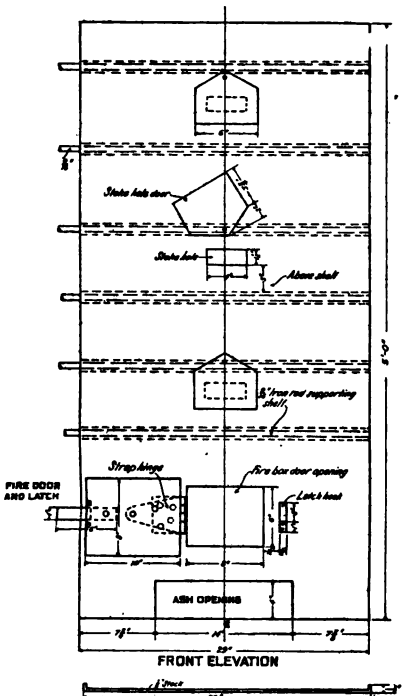
Possible criticisms of the apparatus.—(1) The principal and it is believed the only criticism of moment is that the iron shelf supports and plates will not stand up for an indefinite period under the great heat generated in the apparatus. The answer to this criticism is that all that is necessary to prevent the plates and their supports from sagging is to see that they do not get heated beyond a faint tinge of red. This requires no especial skill, but merely an intelligent and trustworthy man to run the apparatus, who is stationed alongside the fire door and who, from time to time, looks through the little stoke holes for the lowest shelf and in this way the apparatus can be controlled perfectly, since as soon as the shelf shows a tinge of red the check draft doors, which fit quite tightly, are closed up and, if necessary, the fire door opened a little in exactly the same manner as one handles the ordinary household steam fire plant. Under any circumstances only the two or three lower shelves ever get hot enough to sag. Under daily use they would probably last many months, and the cost of their renewal would be negligible as compared with the amount of fuel consumed in an ordinary company incinerator. (2). The apparatus is likely to crack from the intense heat. This is a perfectly legitimate criticism and the answer is that every other furnace in which intense heat is generated will do the same thing. Serious cracks are obviated by backstays, which we have not put on the apparatus we have built up to date, but which should be put on where it is designed for continuous hard use. (3) The number of men required to run the apparatus is from three to five, more than is required to run, for example, a Guthrie incinerator for company use. This is true, but when it is considered that if each company in the division has its own incinerator and at least one man to run it, the total number of men employed in burning garbage in the division is many, many times that required with a central incinerator such as this. When one compares the ease of building, the great cheapness and small space required by this incinerator, as against the enormous expense and skilled care needed by some of the incinerators installed in our cantonments, and when one reflects that it requires no fuel, its real advantage is very apparent.

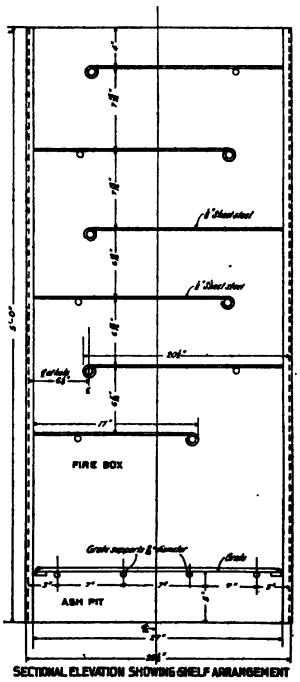
PORTABLE MULTIPLE SHELF INCINERATOR.

MULTIPLE SHELF INCINERATOR.

Barrel type.

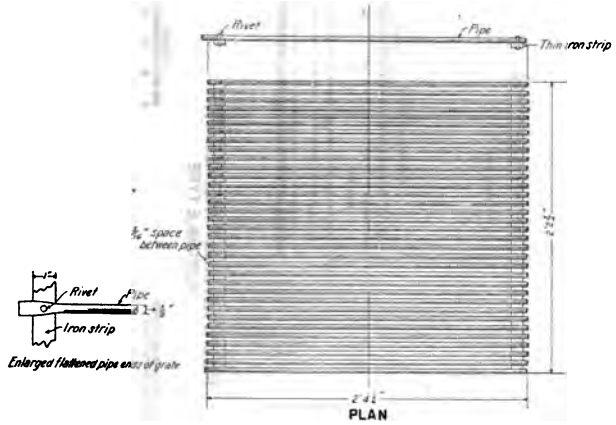
PORTABLE MULTIPLE SHELF INCINERATOR KNOCKED DOWN READY FOR SHIPMENT.





MULTIPLE SHELF INCINERATOR
PORTABLE TYPE

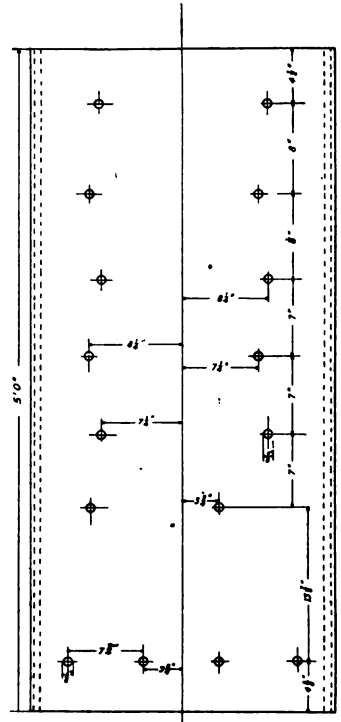
Scale:



PLAN

DETAIL OF GRATE

DETAIL OF WALL JOINTS



SIDE VIEW SHOWING POSITION OF HOLES FOR SUPPORTS OF SHELVES AND GRATE.

MULTIPLE SHELF INCINERATOR

PORTABLE TYPE

An analysis of the ash was made by Prof. F. J. Newman, acting head of the department of chemistry at Kansas State Agricultural College, and is as follows:

The total phosphorus was 4.42 per cent, which is equivalent to 10.11 per cent P_2O_5, water soluble potassium was 1.81 per cent, which is equivalent to 2.18 per cent K_2O.

The ash showed a thorough burning of the garbage, and from the phosphorus and potassium content I would class this as a high-grade ash for fertilizer purposes. In this mixed form of phosphorus and potassium it seems to me that it would have its greatest commercial value. As numerous commercial fertilizers are on the market at the present time containing as much potassium as this ash shows, it seems to me that it would be of most value in this mixed form.

QUANTITY OF MATERIALS.

Common brick		4,300
Fire brick		1,000
Cement	bags	40
Sand	cubic yards	4

Shelves are of boiler plate, ¼ inch for the upper shelves and preferably a little heavier for the two lower shelves. Shelf supports are of wagon tire, ½ by 4 inches. For lintels, strips of wagon tire or railroad fish plates, and for the doors ⅛-inch sheet iron; 1-inch and 2-inch pipe are used for the grate bars.

PORTABLE TYPE.

Designed by Lieut. Col. Charles Spencer Williamson.

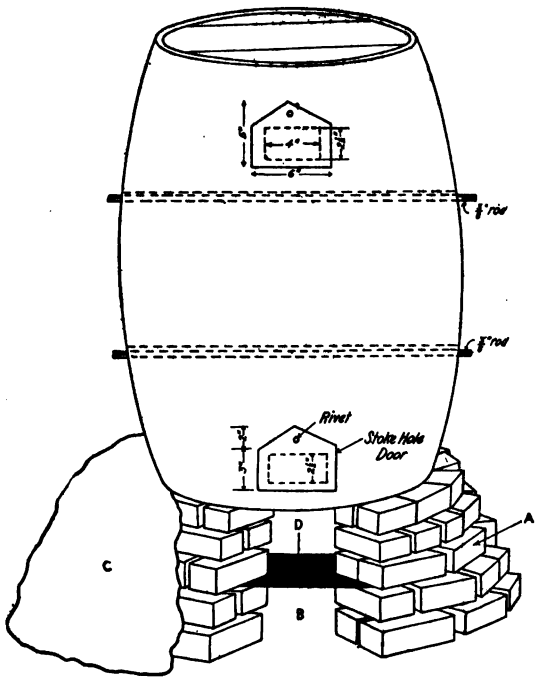
In camps or cantonments, where transportation is easy, it is almost invariably wiser, in the interests of economy of both men and money, to transport the garbage to a central incinerator. There arises, however, conditions under which organizations may remain only a week or two in camp and, under such circumstances, a permanent brick incinerator is not advisable. Our laboratory has, therefore, striven to devise a portable type of the multiple shelf incinerator to meet these conditions. A large amount of experimentation has led us to the conclusion that it is best to design but one such type and one size. The reason for this is the following: The portable incinerator, as finally adopted by us, is of sufficient size to dispose of the garbage of a regiment, assuming that the production of garbage is seven-tenths pounds per man per day, and, at the same time, this incinerator is sufficiently small to be used for a battalion or, even if desired, for an isolated company. Our preference is decidedly in favor of its being used by a battalion or regiment, preferably the latter. While it is simple in its use, it requires the constant attention of one or two men and, in an organization the size of a regiment, it is easy to find one or two trustworthy men who will not abuse the apparatus. The constant objection to various sanitary appliances is, that they will not stand unlimited abuse. Neither will a horse or a machine gun. The solution of the matter is that, if any given apparatus is valuable and will stand reasonable usage, it should not be expected to be used for all manner of purposes for which it is not intended.

The portable multiple shelf incinerator is built of sheet iron, is 5 feet high and a little over 2 feet square, the number and arrangement of the shelves being practically identical with that of the larger ap-

paratus. The method of operation is precisely the same. In other words, it is virtually a miniature edition of the large apparatus except that the walls are made of sheet iron and not of brick. We have already seen that the large model is an absolutely fuelless incinerator, inasmuch as it uses no fuel after the initial charge. This can not be stated to be true of the portable type, since the sheet-iron walls allow of considerable radiation, which in the brick model is almost entirely obviated by the heavy brick walls. The fuel consumption, however, is so small as to be practically negligible. Repeated tests, including several in fairly heavy rains, have shown that it will consume the garbage of a full regiment in 12 hours with the consumption of 53 pounds of wood. Another test showed that it would consume the garbage and the feces of a battalion with an expenditure of 57 pounds of wood in the same period of time. The fuel consumption is, therefore, extraordinarily small as compared with any of the ordinary types of incinerators and its capacity is many times as great. The weight and space occupied by it are so small that transportation is a simple matter. Inasmuch as it is made of sheet iron it can be readily constructed with unskilled labor and, if it buckles, can readily be reshaped with any ordinary hammer. Parenthetically, it may be remarked that the amount of buckling is surprisingly small, since the shelves brace the apparatus very thoroughly. The one which we have pictured and used was constructed in the field, using a railroad rail for an anvil and a machinist's hammer.

The outstanding features of this device are as follows: The front, back, and sides all takedown and can be packed together to make a package approximately an inch thick. The grate, made of light pipe, is in one piece, and the shelves are all takedown, so that the entire apparatus, when put into a flat canvas bag for transportation, occupies less space than an open litter and weighs only 235 pounds.

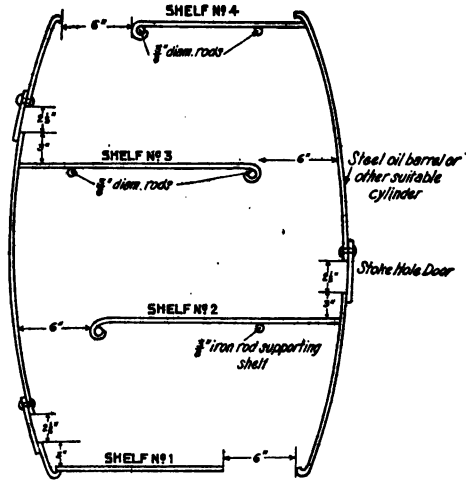
Important details of construction.—The grate is, as shown, made of three-eighths-inch pipe, and the space between these should not be more than five-sixteenths or three-eighths of an inch, since, as already noted in the large type of apparatus, burning garbage is like burning slack coal, in that it is so fine that it falls through the grate into the ash pit. A second point is that the shelves, when turned over on one edge so as to permit the rods slipping through them, should fit very loosely, as otherwise the inevitable corrosion will make them stick. In the small drawing showing the corner it will be noted that the nail there shown holding the two parts together is only put there until the shelves can be slipped in. After that the shelves and grate hold the apparatus firmly together. The material used by us has been ordinary 16-gauge black sheet iron. In assembling, the four sides are set up first and held in position with a few nails put through the small holes. The grate supports and the grate are put in place, then the shelf supports and shelves, beginning with the lowest. In operating care should be taken to have no hotter fire than necessary, just as in the larger apparatus, to avoid unnecessary buckling. In the same way the garbage should never be raked down onto the fire bars until it is absolutely dry, as otherwise the fire will be put out. Once in operation, a very little wood, every hour or so, will suffice to keep it going briskly. The shelves should be loaded not deeper than 1½ or 2 inches with the garbage.



FRONT VIEW

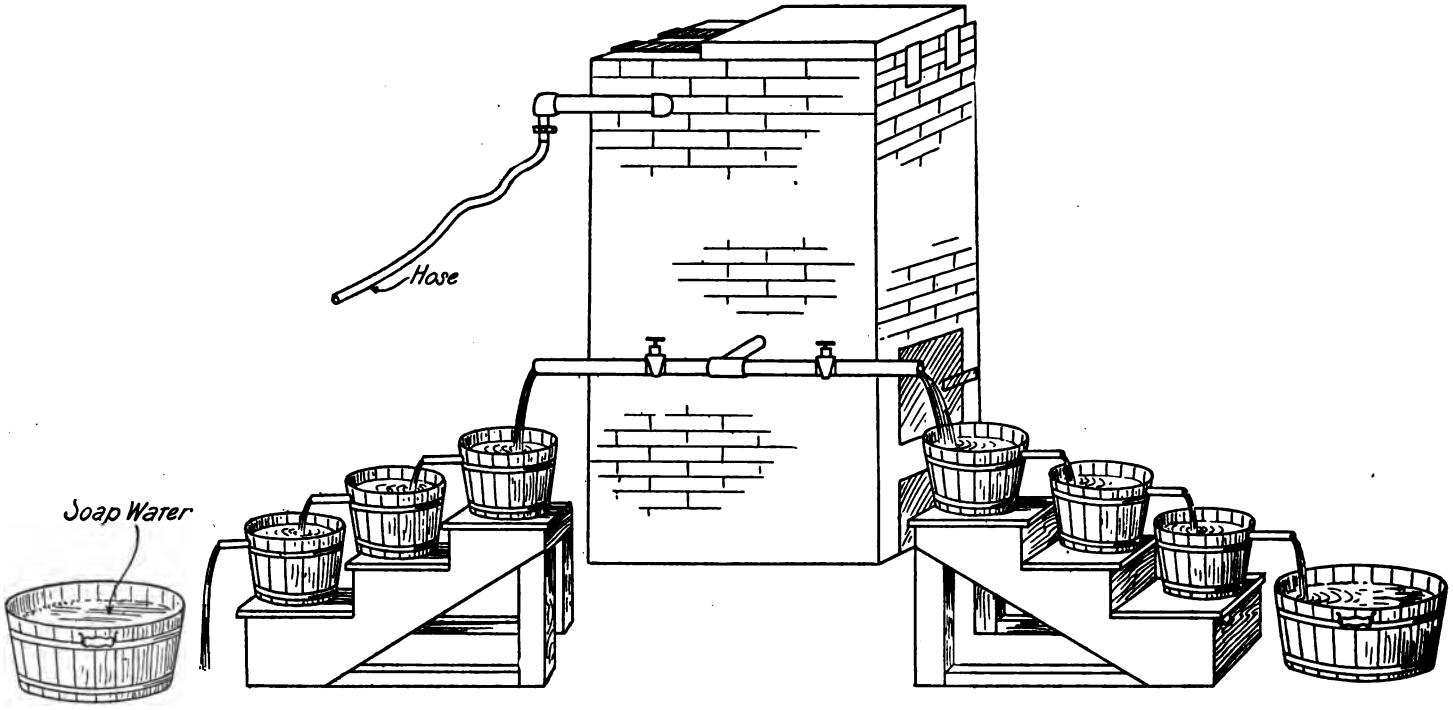
LEGEND.

A—BRICK SUPPORT FOR BARREL.
B—DRAFT OPENING. A PIECE OF TIN SHOULD BE PROVIDED FOR OPENING TO CONTROL DRAFT
C—BANKING OF DIRT.
D—GRATE



SECTIONAL ELEVATION

IMPROVISED MULTIPLE SHELF INCINERATOR BARREL TYPE



THE WILLIAMSON WATER HEATER AND
MESS KIT WASHING ARRANGEMENT

POSSIBLE IMPROVISED TYPE.

Designed by Lieut. Col. Charles Spencer Williamson.

This is nothing more nor less than an ordinary metal oil barrel, arranged with four shelves, as shown in the illustration. The bottom, suitably cut, serves for the lowest shelf. The top is entirely cut out, a suitable sized piece removed and ultimately replaced. Two other shelves are placed in between, as shown in the drawing, and small stoke-hole doors are cut opposite each shelf. While this device is but a very crude one and while it has no possible claim to be considered as anything more than a makeshift, yet it is far better than the ordinary open company incinerators which are still so prevalent. Nowadays an oil barrel is almost everywhere obtainable, and it lasts indefinitely. The fuel consumption is much less than in an open incinerator and it is not so much affected by wind and rain. It will incinerate the garbage of a full company in eight hours with less than 100 pounds of wood.

MULTIPLE-SHELF WATER HEATER AND MESS KIT WASHING ARRANGEMENT.

Designed by Lieut. Col. Charles Spencer Williamson.

This water heater is a direct outgrowth of the multiple-shelf incinerator and the basic principle is identical in the two, namely, to have the fire and hot gases pass around a series of shelves arranged as baffle plates until practically all of the heat is absorbed by the shelves and their contents. In the water heater the shelves, instead of being made of iron plates, are composed of coils of pipe and the different shelves are connected together so as to form one continuous pipe, through which the water flows. Inasmuch as the coils of pipe can not be made without some space intervening between them, a thin piece of sheet metal is laid on top of each coil, so as the more perfectly to deflect the hot gases. The current of water flows in from the hydrant to the top shelf, passes through the connecting pipe to the second shelf, and thus through all six shelves, after which it flows out through the outlet pipe. Substantially this heater is like the well-known commercial types of instantaneous heaters, except that the piping is arranged in the form of multiple shelves, which makes for greater economy in the use of fuel and gives greater capacity. Inasmuch as this capacity is relatively very large, there must be provision made for a rapid flow of water through the coils, failing which steam will generate so rapidly as to kick back. By far the best means of securing this is a direct attachment to a three-quarter or 1 inch water connection, although a large tank could, of course, be used if there is sufficient elevation to pipe the necessary pressure. It should be emphasized, however, that this heater is far too powerful to work satisfactorily by simply leading the two ends of the pipe composing the coils into a tank, after the fashion of the ordinary household water heater.

The apparatus consists essentially of a brick stack approximately 5 feet high and 2 feet square, inside diameter. It should be lined with fire brick if it is to be subjected to hard use. In front is a small

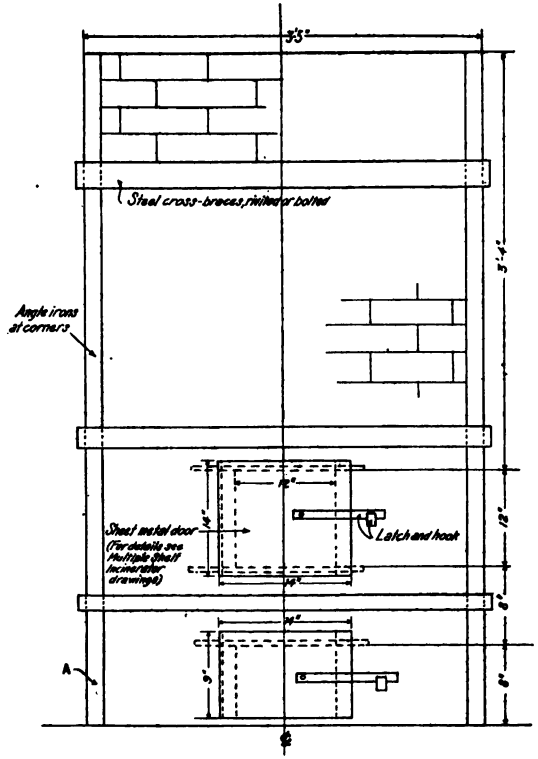
fire door and an ash door, as shown in the drawing. The grate, if wood is to be used, can be made of three-quarter or 1-inch water pipe or any similar material, and the openings between the grate bars should not exceed three-quarters of an inch or even a little less. The grate bars may be built directly into the stack, being careful to allow for their expansion. It is desirable to use an iron lintel for the top of the ash door and the bottom and top of the fire door. We have used with satisfaction pieces of heavy wagon tire for this purpose. The doors are made out of heavy sheet iron and the hinges are arranged as shown in the small drawing. A careful inspection of the arrangement of the coils shows that the individual shelves, of which there are six, are readily separated from one another, the only connection between them being a short nipple. This is a great convenience in that it enables the shelves to be taken apart for transportation or possible repairs, if this should be found desirable, without unscrewing the pieces of pipe composing the individual shelves. The stack having been put up, and being square and true inside, the coils are now put together. It will be noted that each coil is put together with a plain ell and a street ell instead of using return bends, the latter of which cannot be used because of insufficient space to permit of their being screwed together. The distance between the shelves is regulated by the length of the nipple used to connect them. We have made the shelves 4½ to 5 inches apart, which is accomplished by using 3-inch nipples for connections. Less than this distance between shelves is undesirable, and more than this is unnecessary. The lowest shelf is so placed as to be 24 inches above the grate bars, which gives a suitable sized combustion chamber where wood is the fuel. The shelves are made of 1-inch black pipe, using six pieces for each shelf. This arrangement fills up about 18 inches of the stack, leaving 6 inches free. The sheet metal covering the shelf is cut a little larger, so as to reduce the opening to about 5 inches, the same distance as between the shelves, so that the flue space is the same all the way up.

The height of the stack is such that when all six shelves are in place the top shelf is 5 or 6 inches below the top of the stack. To keep the heat in as much as possible a heavy piece of sheet metal, or better still a thin slab of concrete, is put over the top of the stack, leaving a 5-inch slit as the flue exit, this latter being, of course, placed on the side opposite the flue opening of the shelf just below. We have experimented with different numbers of shelves and find six to be the most satisfactory number, taking all things into consideration. It will be noted that the first piece of pipe in the top shelf and the last piece in the lower shelf are longer than the others. This is for the purpose of passing through the walls to connect with the hydrant at the top and with a receptacle for the hot water below. When the stack is being put up a brick is left out for each of these pipes at the proper height, and these two are screwed in after the shelves have been lifted into the stack, supported by the hangers. These hangers are merely two U-shaped iron straps made out of light wagon tire through which holes are drilled at proper intervals and short cross pieces of wagon tire bolted to these two arms with stove bolts. When the shelves have been made and put together properly these hangers slip in between the shelves and the hangers are now lifted into the stack. The two longer pieces above referred to are now screwed in and the

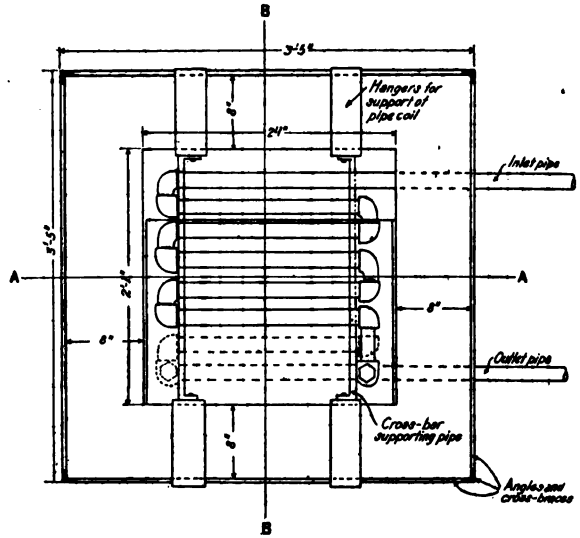
MULTIPLE SHELF WATER HEATER; SHELVES AND HANGERS REMOVED FROM BRICK STACK.

MULTIPLE SHELF WATER HEATER.

Small size.



FRONT ELEVATION

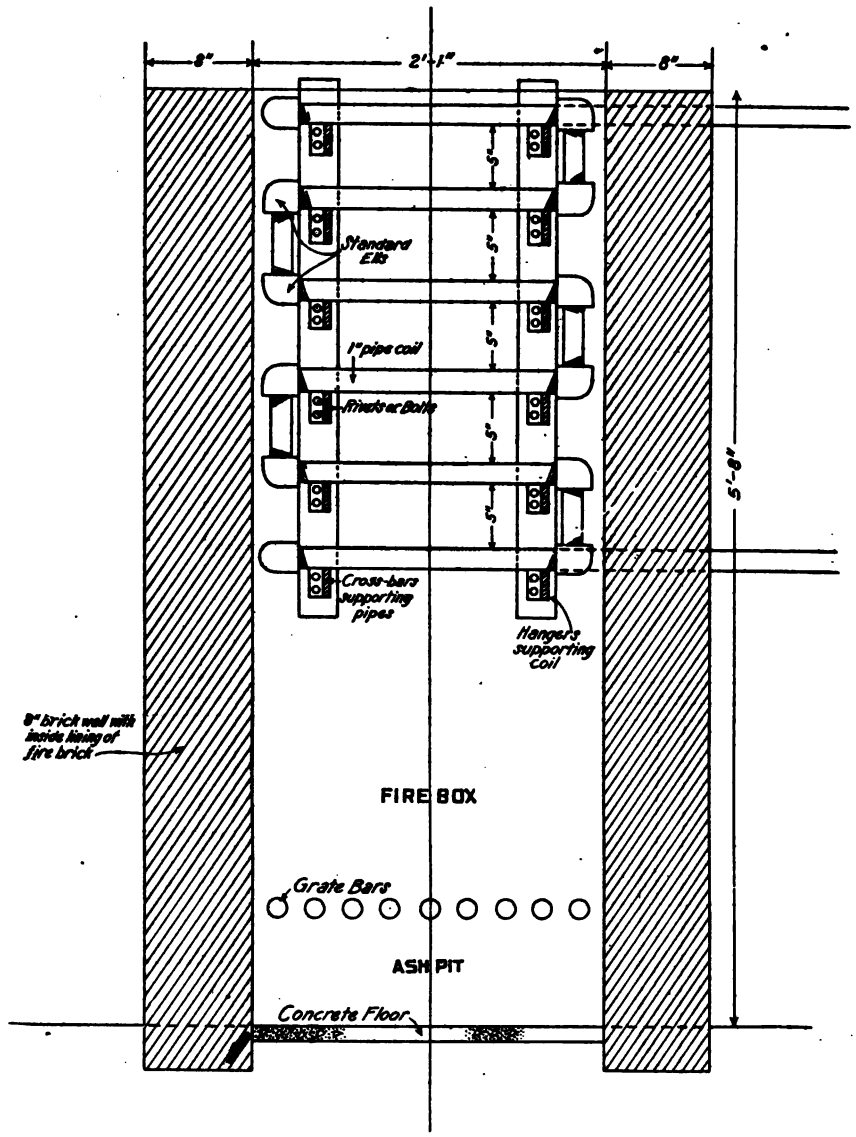


PLAN SHOWING WATER COIL

SCALE

0" 3" 6" 9" 12"

WILLIAMSON WATER HEATER



SCALE

0" 3" 6" 9" 12"

VERTICAL SECTION, FRONT REMOVED

WILLIAMSON WATER HEATER

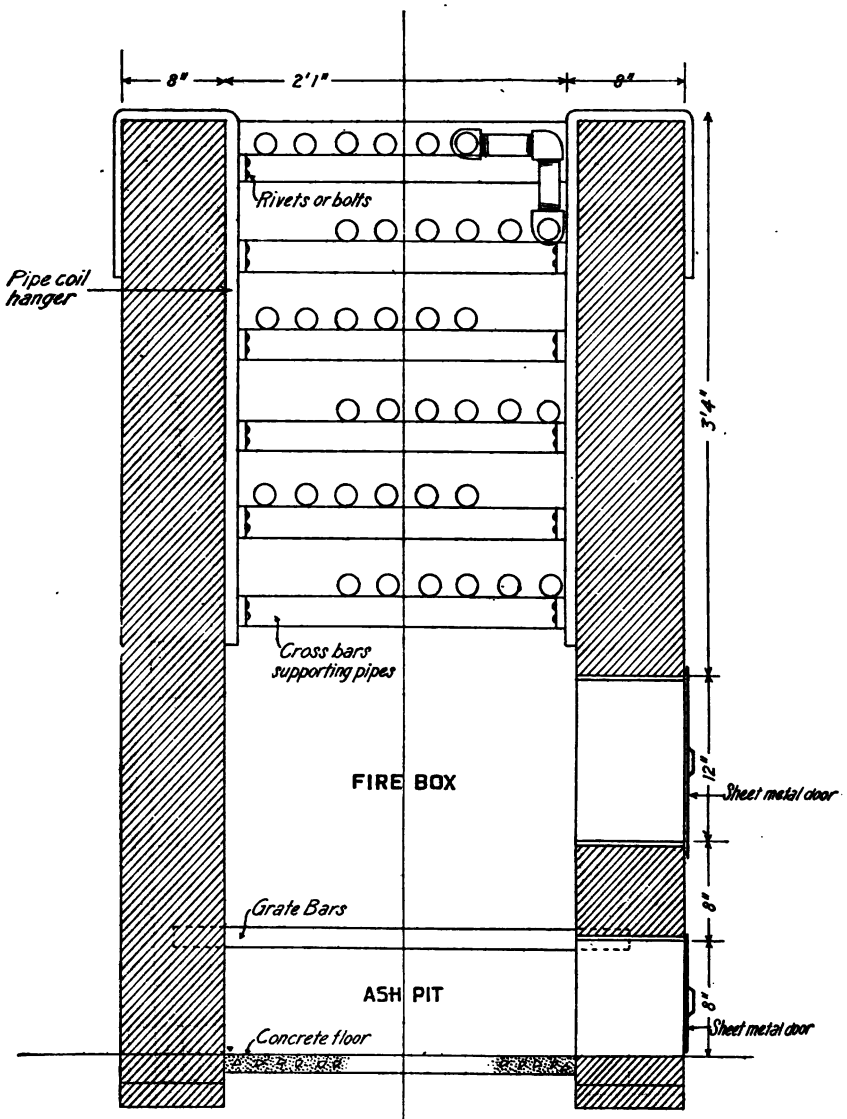
heating apparatus is complete. A 1-inch slide valve is now screwed onto the exit pipe to control the flow. It is important that a slide valve (cut-off) and not a stopcock be used, since a stopcock will not admit of a sufficiently rapid flow under ordinary water pressures. The intake pipe may be connected in any way most convenient with the water system, but at least a three-quarter inch pipe is necessary. To use the apparatus the gate valve is opened slightly, so that a very small stream of water comes through and the fire is now lighted. Within six minutes the water will have become so hot that it is necessary to open the valve a little more and within 10 minutes, or 12 at the outside, the apparatus should have reached very nearly its maximum capacity. With the sized apparatus just described, namely, 2 feet, inside diameter, the capacity, as shown by repeated tests, is a little over 1,800 gallons in a day of eight hours, heating the water from a temperature of 2° C. (36° F.) at the inlet to 70° C. (158° F.) at the outlet. The one disadvantage with this heater, if it be indeed a disadvantage, is that it can not well be turned off when not in use without drawing the fire, as is of course possible when gas is used as fuel. If a tank be provided, say, composed of 3 or 4 barrels connected together, or any other suitable arrangement, a T-pipe can be arranged so that the water can be allowed to run into the tank when not being used. It is apparent at a glance that the temperature of the water at the outlet depends upon the rate of flow, and by adjusting the slide valve this can be varied to within almost any limits. If, with a given stream, the temperature of the emerging water be 65° C. (149° F.), shutting off the flow a very little more will run the temperature up to 165° or 170° F. and a little further diminution in the stream will run it up to 190° or 195° F. The primary design of this heater is to give hot water quickly and in large quantities with a small fuel consumption. It is not designed to give boiling water, although by watching the valve carefully water at a temperature of 95° C. (203° F.) can readily be obtained. This great flexibility is one of the chief advantages of the apparatus. If, for example, the apparatus is running at the rate of 200 gallons an hour at a temperature of 150° F. and it is desired to have a few buckets of water at a temperature of 200° F., all that is necessary to do is to give a turn to the handle of the valve and within a minute the water emerging will be at the latter temperature and will continue at this temperature indefinitely. If water of a lower temperature is desired the valve is opened a little and instantly it is to be had.

It should be noted that even this smallest form of apparatus, just described, is much too large for company use unless it is connected with a bathhouse, for which purpose, however, it is not primarily designed. One such apparatus, which we have installed for the service company at Camp Greenleaf, took care of three companies, giving them all an abundance of water for mess kits and similar purposes. Anybody who has seen the ordinary filthy arrangement of three or four buckets arranged on a Guthrie or similar incinerator and, with these three or four buckets, perhaps 200 mess kits are washed, the water at the end looking like liquid swill, will appreciate the arrangement shown in the small sketch for washing mess kits. This arrangement is very simple, the outlet pipe has two arms, each about 3 feet in length, connected with a T, so that the emerging

stream of water is split in two. Six small half barrels are now arranged, as shown in the drawing, the water flowing out of the first receptacle into the second and then into the third. Two lines of men can wash their mess kits on each side, so that four lines of men are constantly passing by. In addition to this, a tub of soapy water is used for the first washing, so that each mess kit is first washed in soapy wafer and then in three separate flowing waters, being constantly renewed, the last of which has a temperature of about 75° C. (167° F.). The economy and sanitary efficiency of this arrangement leaves little to be desired. The fire can be started 20 minutes before mess kits are to be washed and in that time the small half barrels are filled with hot water ready to begin. The fire is allowed to die down as the end of the line is reached and is remade at the next meal, so that all the waste of fuel for the four or five hours between meals is avoided. The amount of time required to wash a given number of mess kits by this method is less than one-half that required where the same organization had an incinerator for each company with six buckets of water on each incinerator. Where the fire is maintained hot enough in these incinerators to keep the water at a satisfactory temperature it is difficult for the men to get near them and the washing is done in a most superficial manner. In view of the late opinions with reference to the transmission of diseases such as influenza by improperly washed utensils, these points are of more than ordinary importance. It is worthy of note that the men themselves, as well as the officers of the company, are delighted with the arrangement and, at this present writing, several more have been installed. One heater is subserving a different purpose, namely, to furnish hot water to start the motor trucks on very cold mornings.

In regard to the size of heater necessary for a given purpose the data already furnished will give the necessary information. It is perfectly obvious that, with the same number of fittings, the capacity of the heater could be greatly increased merely by lengthening the individual pipes making up the shelves, leaving the number of these unchanged and, of course, increasing the size of the stack in the same dimension. With the inside diameter of the stack, 24 by 36 inches, a 50 per cent greater capacity can be obtained. With this size heater, constructed at our experimental laboratory, an eight-hour test, made on December 30, 1918, produced 2,574 gallons of water, at a temperature of 70° C. (158° F.) with an expenditure of 485 pounds of a very inferior quality of wood. The temperature of the water at the inlet was 2° C. (36° F.). It has not seemed desirable to construct heaters of larger capacity than these, since there is so rarely a call for this large quantity of water.

Accurate tests were made of a number of the best types of water heaters in use in this camp as compared with this apparatus. Broadly speaking, their fuel consumption varied between three and four times that required by this heater to heat the same amount of water. When one takes into consideration the fact that none of the ordinary heaters have more than one-third the capacity of this, it will be seen that, in economy, convenience, and simplicity it far outranks any of the ordinary type in use in our cantonments. A further great advantage is the fact that the coils may be readily taken down in 10 minutes, thrown in a truck, and taken somewhere else. The



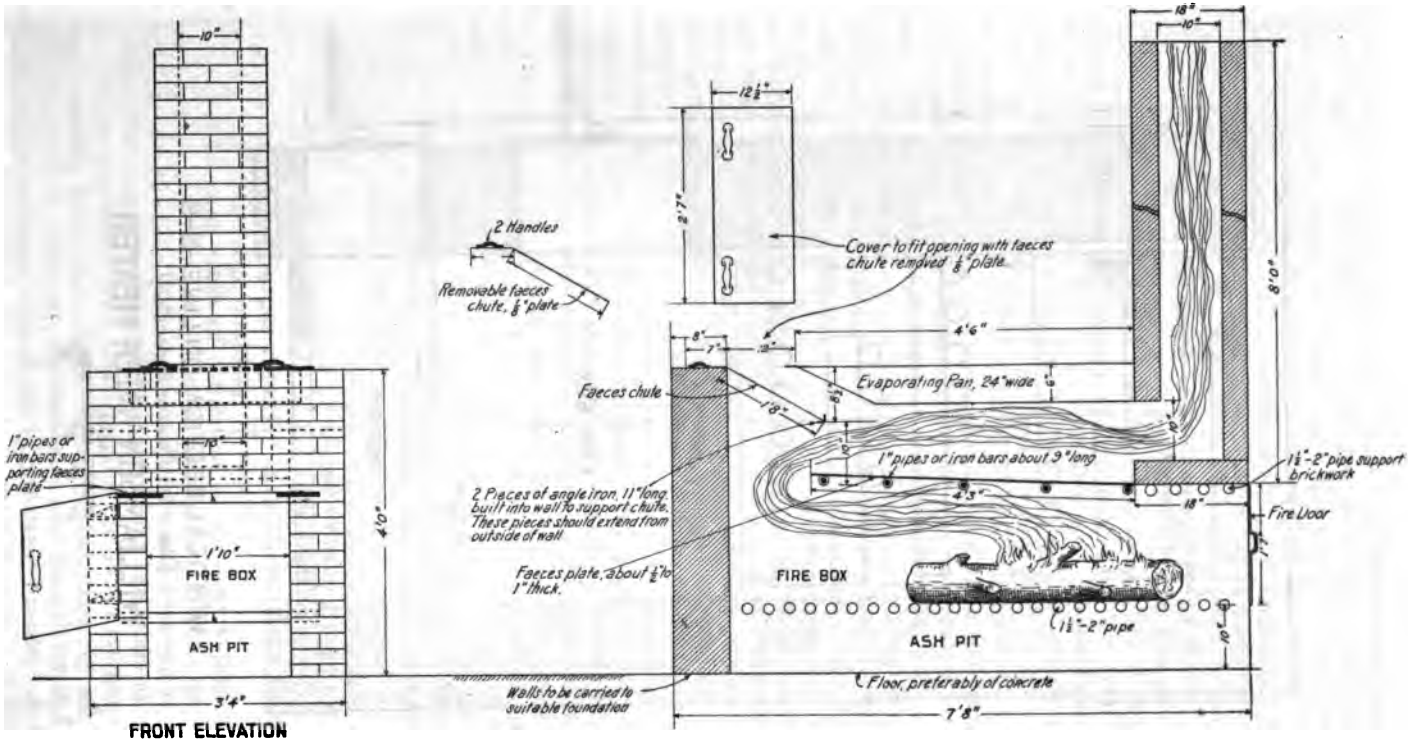
VERTICAL SECTION ON LINE-B-B

(See Plan Showing Water Coil)

WILLIAMSON WATER HEATER

SCALE

0" 3" 6" 12"



FORT RILEY- McMUNN INCINERATOR

stack may be built in a day by any good mason. The one disadvantage which has been found, up to date, is that it does not operate well in the absence of a piped water system whereas, of course, buckets or galvanized-iron cans may be used over any kind of an improvised fireplace. On the other hand, this heater is designed for permanent or semipermanent cantonments or hospitals and in these such a water supply is practically always available, so that this disadvantage is more theoretical than real.

To obtain sufficient strength in the construction it is desirable that it be backstayed with some light material. We have used the angle irons from discarded beds which make very satisfactory corner irons, these being held together by ⅜-inch rods, as shown in the diagram. Any other simple arrangement of backstaying may be used.

In constructing the size heater 24 by 36, no change is made except in one diameter of the stack, of course shifting the doors to the center and in the length of the pipe making up the shelves. It is wisest to build the stack first, then to cut the pipes of such length that, when fitted with the ells and screwed home, they will leave a one-half inch play at each end. If this be not done and the stack be not perfectly built, a misfit may result. The bottom shelf should be put together first, being careful to see that the flue opening for that shelf is on the side of the stack farthest away from the door.

MATERIAL FOR MULTIPLE-SHELF WATER HEATER.

(Small size 24x24 inches.)

Black pipe, all 1 inch: 2 pieces, 54 inches, for outlet and inlet; 11 pieces grate bars, 24 inches long; 34 pieces water coil, 18½ inches long; 10 nipples, 3 inches long; 30 street ells, 1 inch; 42 ells, 1 inch; 1 gate valve, 1 inch (cut-off).

Sheet metal, all 12 gauge: 6 heat deflectors, size 19x23½ inches; 1 fire box door, size 14x14 inches; 1 ash-box door, size 9x14 inches; 2 latches, size 1x⅛x12 inches; 2 hasps, size 1x⅛x7 inches.

Brick, 275 fire; brick, 725 common; cement, 3½ bags; lime, 4 bags.

THE FORT RILEY-McMUNN INCINERATOR.

Designed by Lieut. Col. Charles Spencer Williamson.

This incinerator was designed with the idea of utilizing the heat which, in the McMunn furnace, goes to waste. To facilitate accurate comparison it was built of the same dimensions as our McMunn. The chimney and furnace door are placed at the same end, the feces chute at the opposite end. By this arrangement, the flames, passing under the feces plate, as shown in the drawings, are reflected by the feces chute and pass under the evaporating tray and then to the flue. This brings the heat into direct contact with the evaporating pan, as well as the upper surface of the feces plate. This latter plate is of heavy (one-half to one-inch) boiler plate. The feces chute is of light sheet iron and lifts out easily, as it simply rests on the top of the end wall and the two pieces of angle iron imbedded in the wall. The cover is of a simple piece of light sheet

iron. With this construction the feces are readily incinerated and may be raked backward with a small rake with a bent handle or the feces chute may be lifted up and the feces can then be readily raked backward. This incinerator has been thoroughly tested and, with this construction, draws well and is quite efficient. Another arrangement will, of course, be self-evident. By far the greater amount of the heat is utilized in evaporating the urine. While this can be lessened by the use of sawdust, the amount of heat required is still very considerable. Inasmuch as a short boiling sufficiently sterilizes the urine to render it harmless, it might well be removed after boiling and disposed of in a sullage pit. This process, of course, requires supervision, but if a sandy or other absorbent soil, necessary for the successful operation of a soakage pit be at hand, it would decrease time and fuel consumption very greatly, since the incineration of the feces alone is rapidly accomplished. Especial attention is called to the ease with which this incinerator may be built if brick or suitable rock be at hand. All the metal parts are readily removable, so that, in case they become warped by the heat, they can easily be straightened and returned.

This incinerator is not designed for general use, but only for disposing of urine and feces, when these are known to be infected, as from typhoid and dysentery cases.

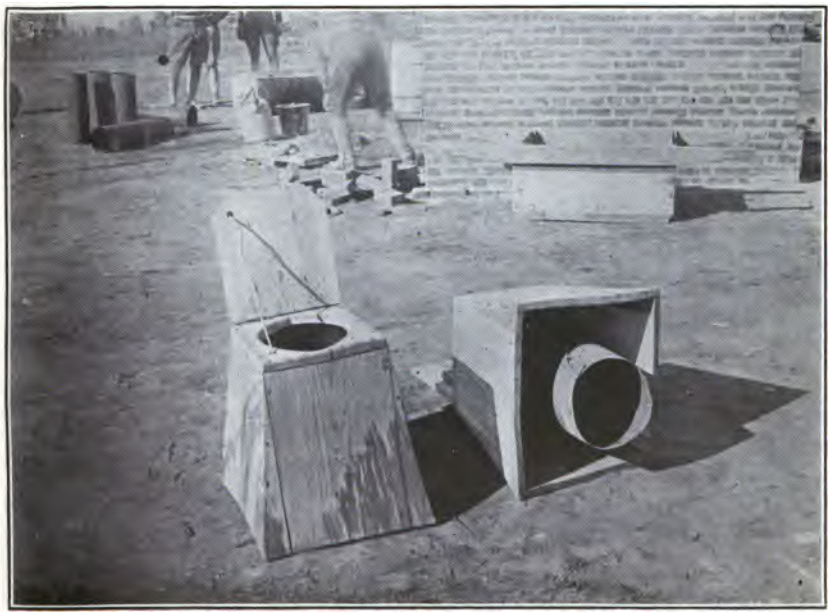
LATRINE TOP FOR POST-HOLE LATRINE.

Designed by Lieut. Col. Charles Spencer Williamson.

Maj. Jepson has suggested the very ingenious device of a series of post holes, with a suitable top for a latrine, using tar paper funnels. In firm ground, which is not rocky, a post hole, 9, or better, 10 inches in diameter and 5 or 6 feet deep, can readily be dug in a very few minutes and the tool required weighs but very little. The only difficulty in the way of this device is the necessity of providing a suitable latrine top. We have suggested and constructed a simple top. In shape it is a truncated pyramid about 18 inches square below and 13 inches square above, the box being 17½ inches high. This is provided with the ordinary type of hinged cover and, to insure this always staying closed, a rope is arranged which permits of the cover opening to an angle of only 85 degrees. A small weight attached to the other end keeps the rope stretched. The useful feature of this arrangement is that a number of them can be nested together. Six of such boxes, complete, weigh 108 pounds, which is, of course, very much less than a standard latrine box of similar capacity. To prevent the urine and feces from soiling the ground or the sides of the box, a funnel is made of tar paper of such a size that it just fits inside of the under surface of the seat and tapers at the bottom so as just to fit into the post hole. These tar paper funnels last for a long time and, as they nest into each other, take up very little room and the weight is almost negligible. They are best cut out, as shown in the diagram, and carried flat. They could, of course, be constructed equally well of tin or any other suitable material. Such a latrine top requires only the simplest of tools and boards of almost any kind for its construction. If desired, three or four of them could be placed over a straddle trench and used in the same way. The post

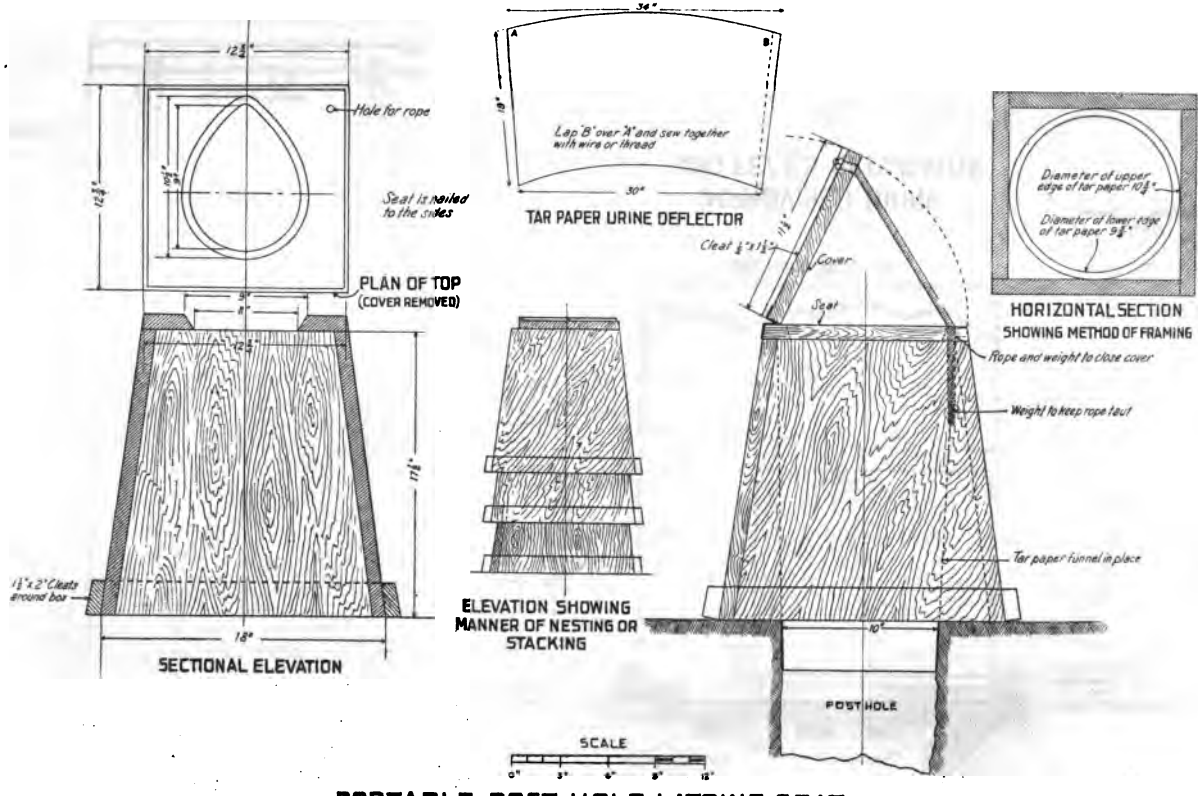
FORT RILEY-McMUNN INCINERATOR (FOREGROUND), OLD STYLE McMUNN INCINERATOR (TO THE LEFT).

Note.—The feces chute is being held slightly raised by the attendant.

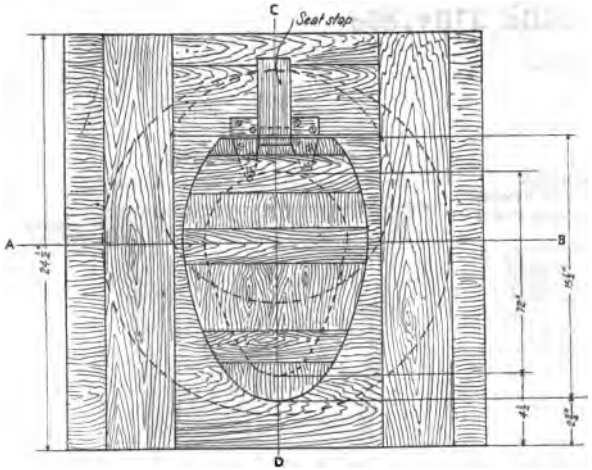


PORTABLE LATRINE TOP FOR POST-HOLE LATRINE.

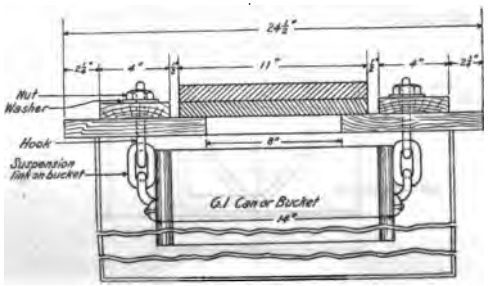
Author's model.



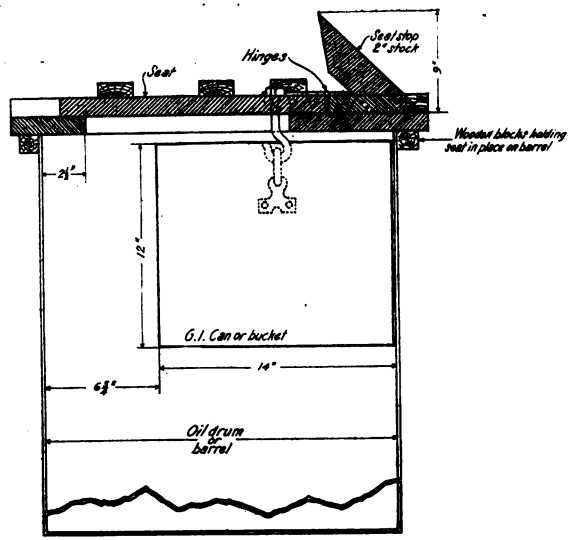
PORTABLE POST HOLE LATRINE SEAT



TOP VIEW



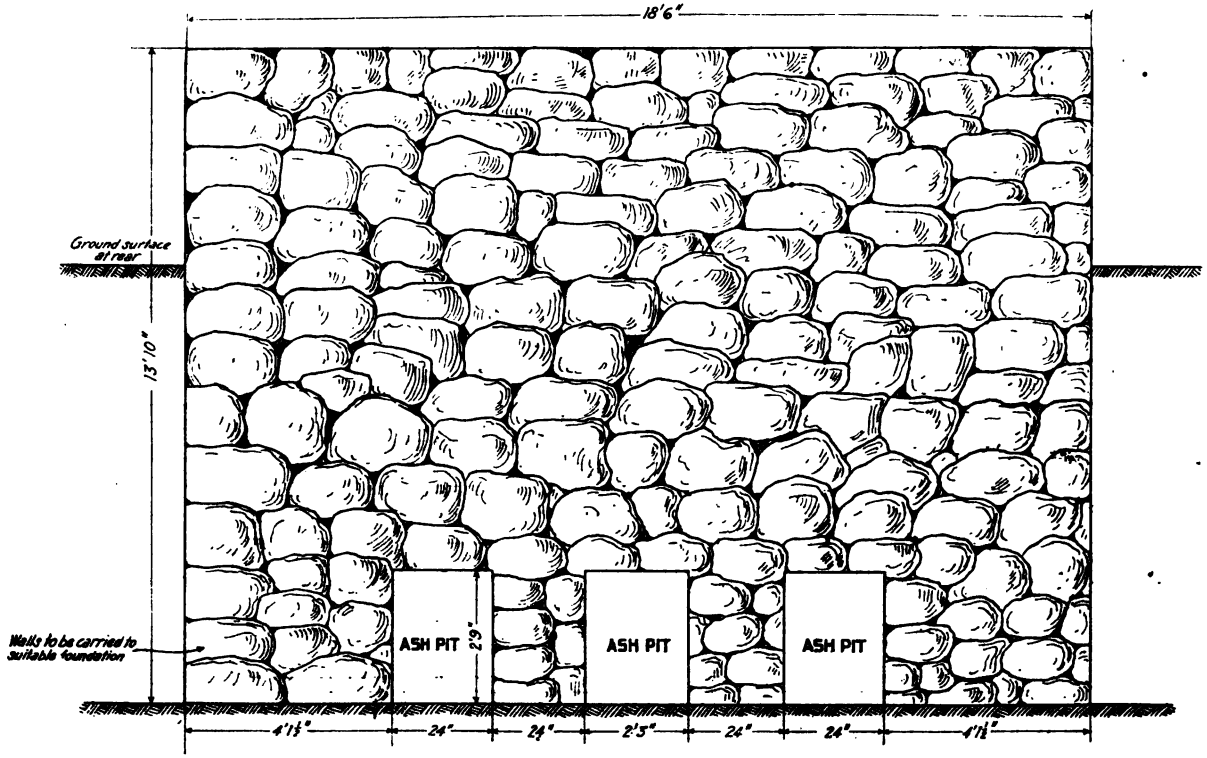
SECTION ON A-B



SECTION ON C-D

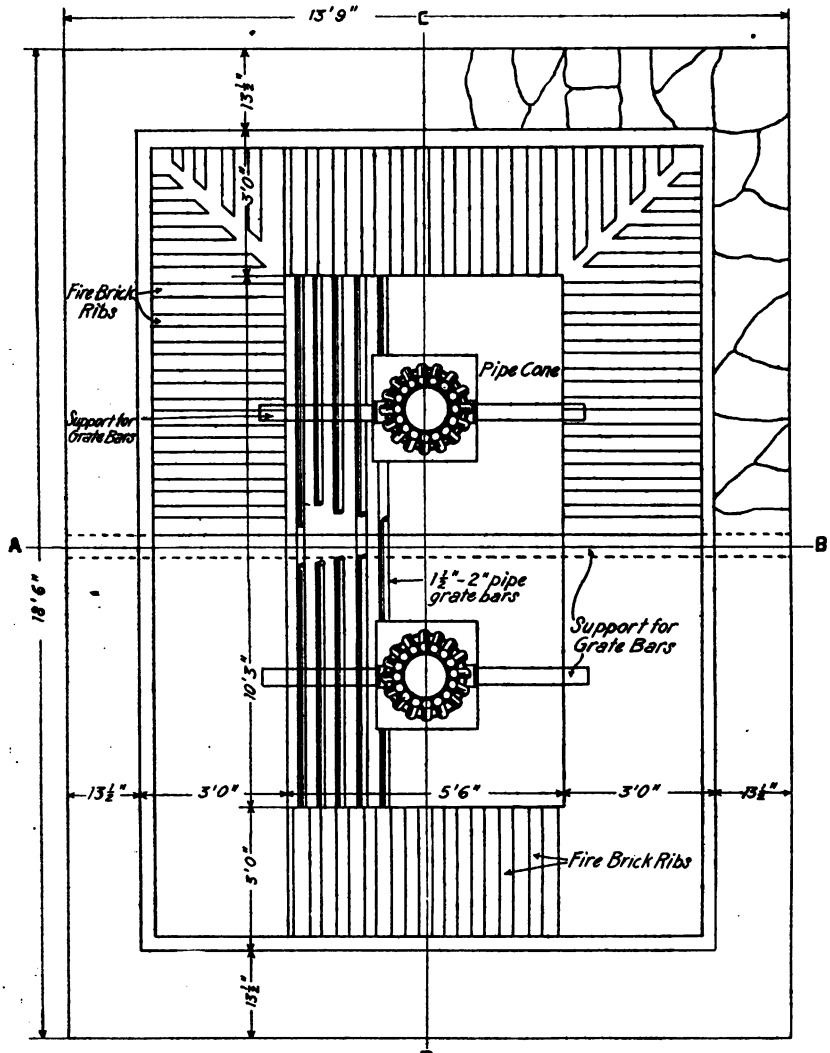
Scale:
0 2" 4" 6" 8"

IMPROVISED URINE AND FECES SEPARATOR



FRONT ELEVATION

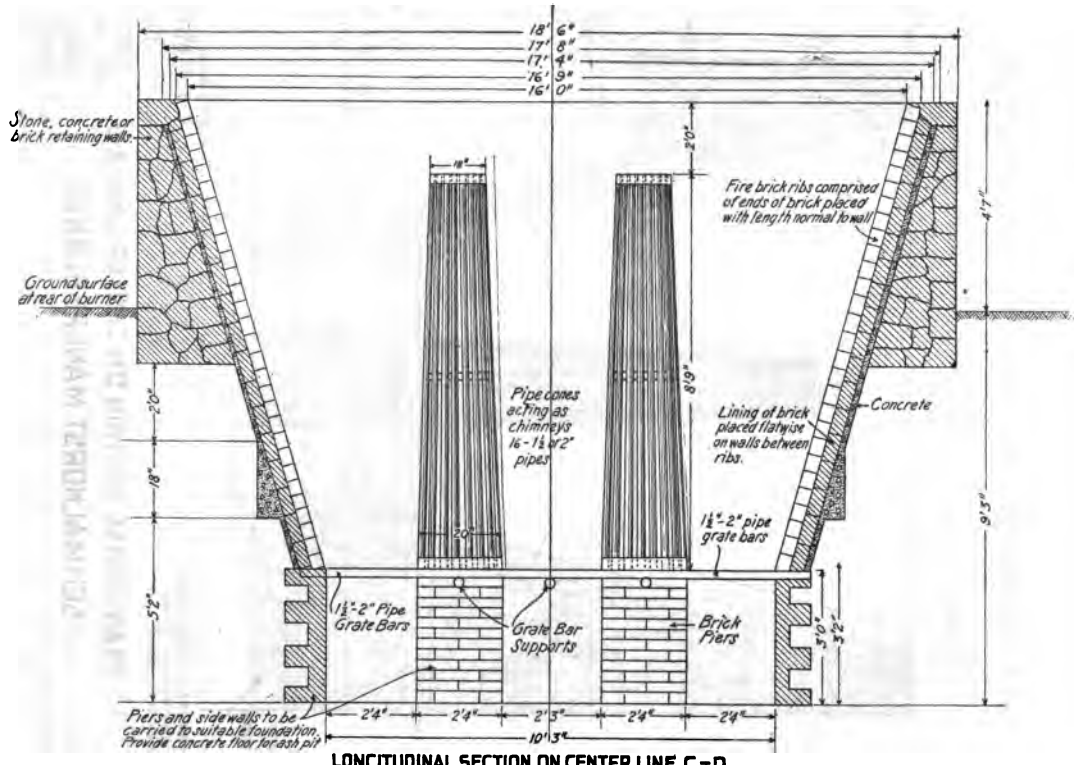
SCHMALHORST MANURE BURNER



PLAN

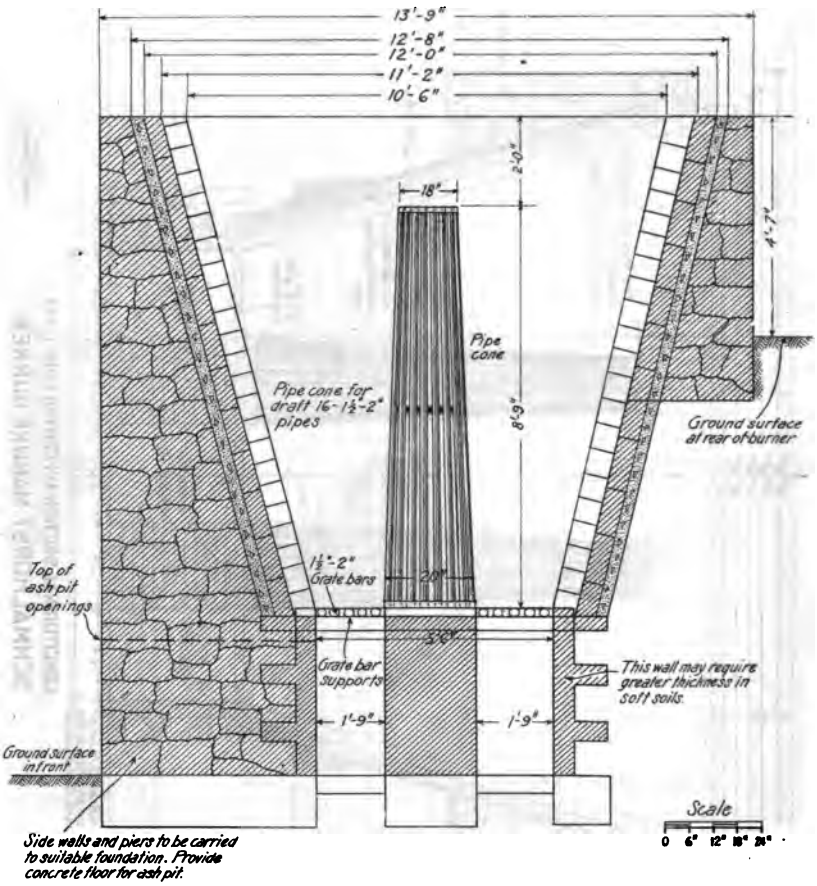
(Burner to be built on side hill if possible)

SCHMALHORST MANURE BURNER



LONCITUDINAL SECTION ON CENTER LINE C-D

SCHMALHORST MANURE BURNER



TRANSVERSE SECTION ON CENTER LINE-A-B

SCHMALHORST MANURE BURNER

hole has, however, the advantage of being less offensive, more easily filled in, and almost equally quickly constructed if the proper tool is at hand. This latrine top would be suitable for a small detachment or for outposts. Three or four, nested together, could readily be carried on a wagon without occupying too much space and would be used in place of straddle trenches, where for any reason these seemed undesirable.

IMPROVISED URINE AND FECES SEPARATOR.

Designed by Lieut. Col. Charles Spencer Williamson.

The present war has shown the very great desirability, indeed, in some cases, the imperative necessity of separating urine and feces, particularly where the latter are to be disposed of by incineration. Innumerable devices have been suggested, many of them impracticable. The important point to be remembered is that, in an improvisation, it is necessary to use standard utensils, since these are the only ones which are likely to be at hand. With this in mind, we have devised this apparatus, using an oil drum or an oil barrel, either metal or wooden, for the outer receptacle and an ordinary shallow galvanized iron can or large pail for the inner receptacle. The top is a light framework, a little over 2 feet square, with the necessary opening, lid and seat stop, as in any other latrine top. From the under side of this hang two heavy hooks which engage in the lips of the pail or if these are not large enough, in two heavy wire loops. The manner of using this latrine is self-evident, the feces dropping into the bucket, the urine into the outside barrel. If desired, and the ground is suitable, the bottom of the barrel may be perforated and the whole apparatus placed on top of a urine soakage pit. This is the most desirable arrangement when practicable. There is nothing new in principle in this device, but it has the added convenience that the top may be taken off for transport without the necessity of taking the rest of the apparatus.

THE SCHMALHORST MANURE INCINERATOR.

Designed by Capt. David E. Schmalhorst.

This is a development of the Canadian type of manure incinerator, which consists merely of four brick walls, with a grate formed of railroad iron, and an ash pit. Many tests of this original apparatus show that one of its main disadvantages is the absence of any openings in the center through which air can circulate enough to facilitate the combustion. The smooth walls effectually prevent any draft or combustion on these surfaces. To overcome these two defects, this modification has been designed. The essential points of difference between it and the original Canadian pattern are the following: (*a*) The sides are sloped at an angle of about 16 degrees from the perpendicular. Along all four sides ribs are made by allowing brick to project outward so that there is a series of small flues which effectually admit of the circulation of air and consequent combustion. (*b*) A number of cones, made of iron pipe, are arranged, fastened together as shown in the diagram. These cones permit

the circulation of air through the mass of the pile of manure and add very materially to the rapidity of combustion.

In efficiency this apparatus is vastly superior to the original form. It requires a little more attention than the original form, since the little flues must be kept open with a long poker to keep the apparatus functioning at top speed. It operates well in spite of wind and heavy rains, its one disadvantage being, in common with all of the usual types of manure burners, that its capacity is too limited to regard it as the final solution of the manure problem for such an organization as a division. Inasmuch as the cost of construction is not great, it might be used during very rainy weather, using the windrow system of disposal during the favorable seasons of the year.

Because of the high degree of heat generated and of the weight of the manure it is highly important that the construction of this apparatus be extremely heavy. The grate should be of heavy rails, well supported by crosspieces and piers.

IMPROVISED URINE AND FECES SEPARATOR.

Designed by Capt. David E. Schmalhorst.

This device consists of a galvanized-iron pail of about 14½ inches diameter, with a snugly fitting top, in which is cut the necessary opening. The top is provided with a metal flap cover, kept closed by a steel coil spring. The pail serves for the outer receptacle. The inner receptacle for receiving the fecal matter is made of a kerosene tin, bent as shown in the illustration. This arrangement makes it possible to manufacture the tops in quantities if desired and use them on the standard pail of the size mentioned. The kerosene tins can be procured almost any place.

DUNNE-WAGNER CLAY OVEN.

Designed by Capts. Dunne and Wagner.

This exceedingly ingenious oven was built after the designs of Capts. Dunne and Wagner, Quartermaster Corps. The general principle of the oven is as follows: A longitudinal trench is dug in the ground to serve as a fire box and this trench is lined and roofed over with clay, the roof being held in position by a suitable wooden form. The oven proper is built on the top of the ground over the fire box. To insure the heat being conducted all around the side and top of the oven a series of flues are made of old tin cans with the ends knocked out and so arranged as to encircle the oven leading from the fire box below to the top flue, which runs lengthwise along the top of the oven and which leads in turn to a chimney. There are six of these flues encircling the oven and, in order to make the distribution of the heat still better two smaller flues connect each pair of adjoining flues with each other. With this arrangement the fire box opening is at one end, the oven opening at the other, and the smokestack is over the fire box opening. The main points to be observed in the construction of this oven are, first, to make a light wooden form for the fire box, another for the oven proper, and a small one for the top flue. As the

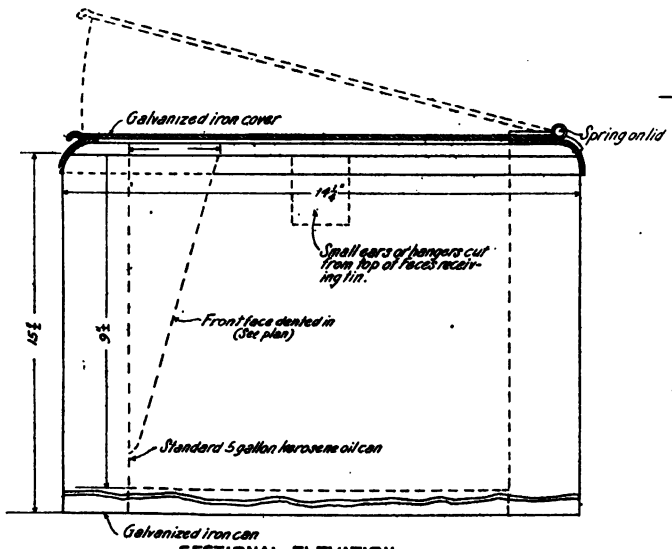
IMPROVISED URINE AND FECES SEPARATOR.

IMPROVISED URINE AND FECES SEPARATOR.

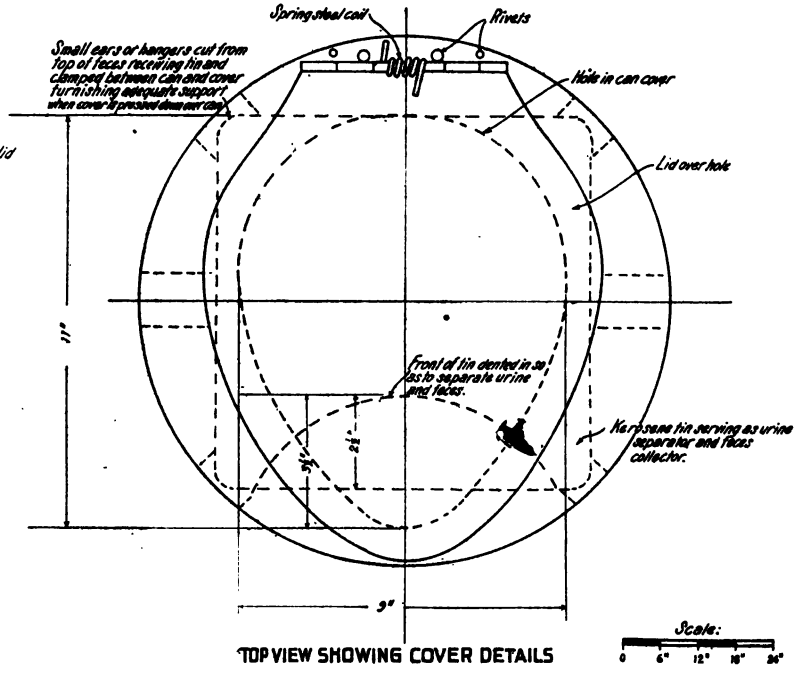
SCHMALHORST MANURE INCINERATOR.

View of front face.

DUNNE-WAGNER CLAY OVEN.



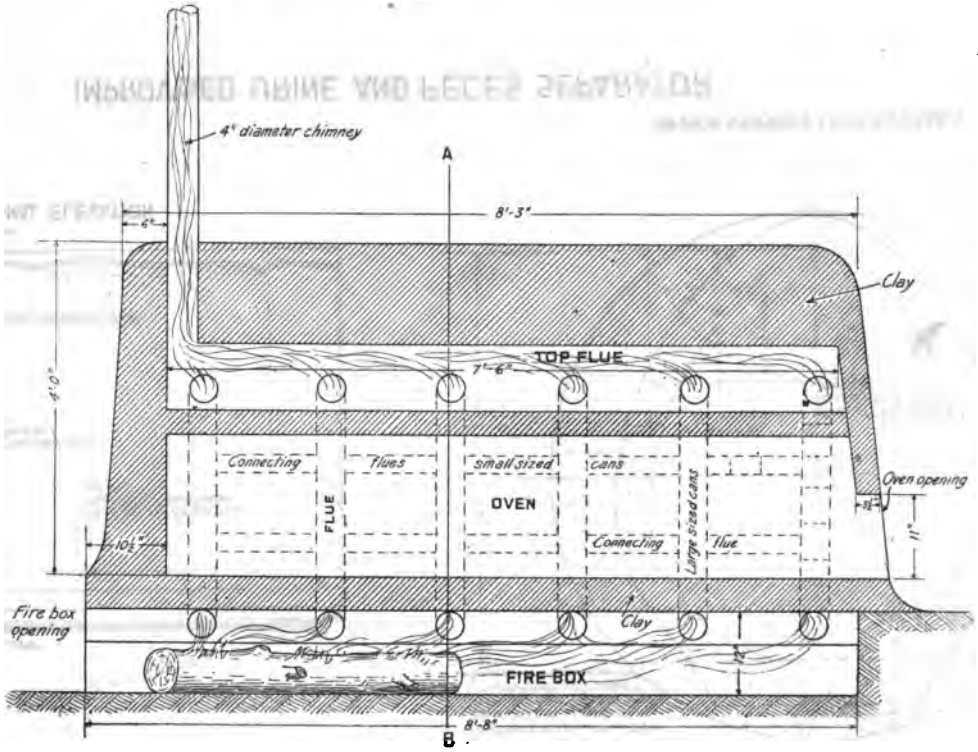
SECTIONAL ELEVATION



TOP VIEW SHOWING COVER DETAILS

24-A

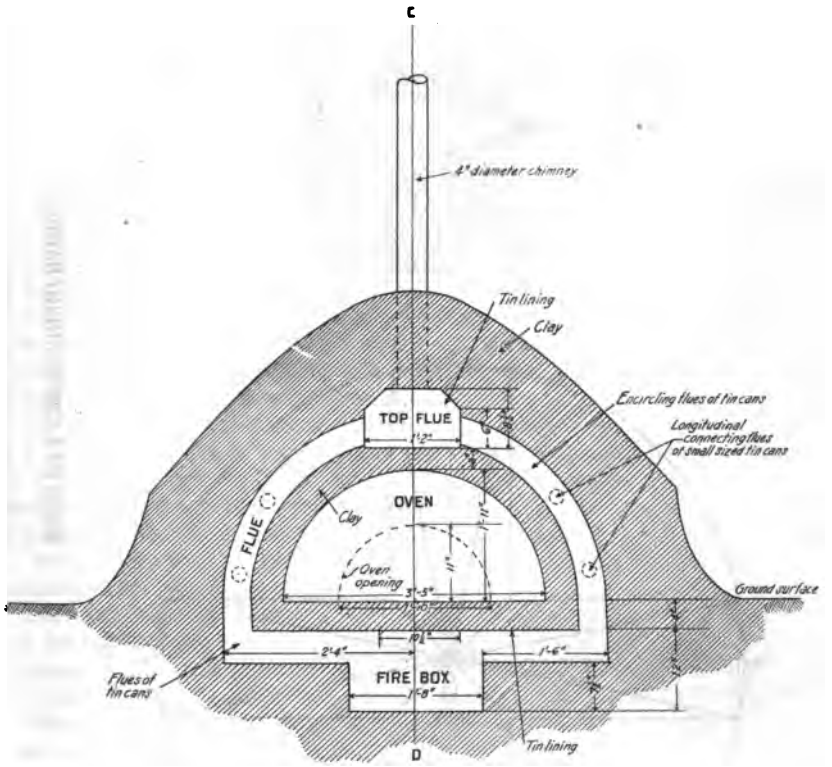
IMPROVISED URINE AND FECES SEPARATOR



LONGITUDINAL SECTION ON C-D

DUNNE-WAGNER CLAY OVEN

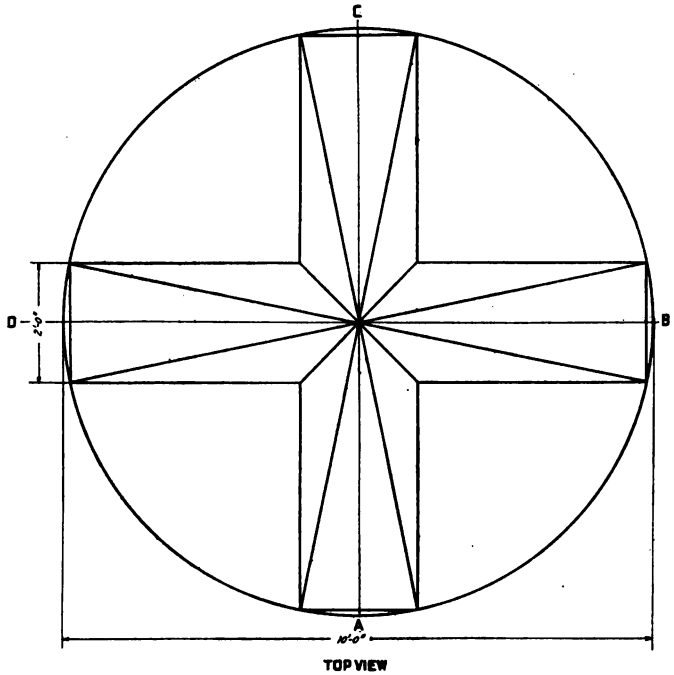
SCALE



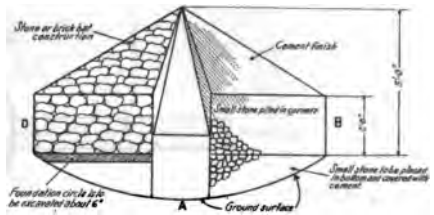
SCALE
0" 3" 6" 9" 12"

TRANSVERSE SECTION ON A-B

DUNNE-WAGNER CLAY OVEN



TOP VIEW



ELEVATION SHOWING A-B-D

ROCK PILE CROSS INCINERATOR

walls, of necessity, must be fairly thick it is well to let them dry out for a day or two. Such an oven must be very gradually baked. If a hot fire be made in it before it is thoroughly dry it is likely to disintegrate. A good plan is to build a very small fire and let this remain for several days before further use. In efficiency this oven leaves little to be desired and, where the necessary tin cans and suitable clay can be obtained, it is exceedingly satisfactory. While this oven is easily built it requires considerable manual labor and a number of days' time, so that it is only suitable for semipermanent commands. Where clay of good quality cannot be obtained its construction should not be attempted.

ROCK PILE CROSS INCINERATOR.

Designed by Maj. Wm. Pretts.

The basic idea of this incinerator was derived from an illustration of an unclassified form of incinerator in Straub's article in the San Diego Maneuver. As constructed by us the central part of the cross is built up to form an apex. Each of the four piers forming the cross is built up to lines from the apex to the outer corners of each pier. Rock or brick or even adobe blocks may be used in the construction. The reentrant angles, in this form of construction, are floored with rocks and then loose rocks are piled in the angles so as to form a rough incline plane toward the apex.

To operate the incinerator the fire is built in the angle opposite to the direction from which the wind is blowing, or if there is little or no wind a fire can be built in all of the angles at the same time. The peculiar tapering construction produces an upward suction in the side opposite to the wind, so that it operates well even with a heavy gale of wind blowing. The rocks piled loosely in the angles present a large surface for the semiliquid material.

This incinerator, while a very crude device, has, in our judgment, one feature which renders is preferable to the ordinary saucer-shaped depressions in the ground which are used as company incinerators; and that is, it does not allow papers and similar light combustibles to be blown all over the camp in high winds. It is, of course, extravagant of fuel, but not more so than the ordinary company rock incinerators. Where the ground is extremely hard and rock is available it is a useful makeshift.

APPLIANCES FROM OTHER SOURCES.

THE OBER FLY TRAP.

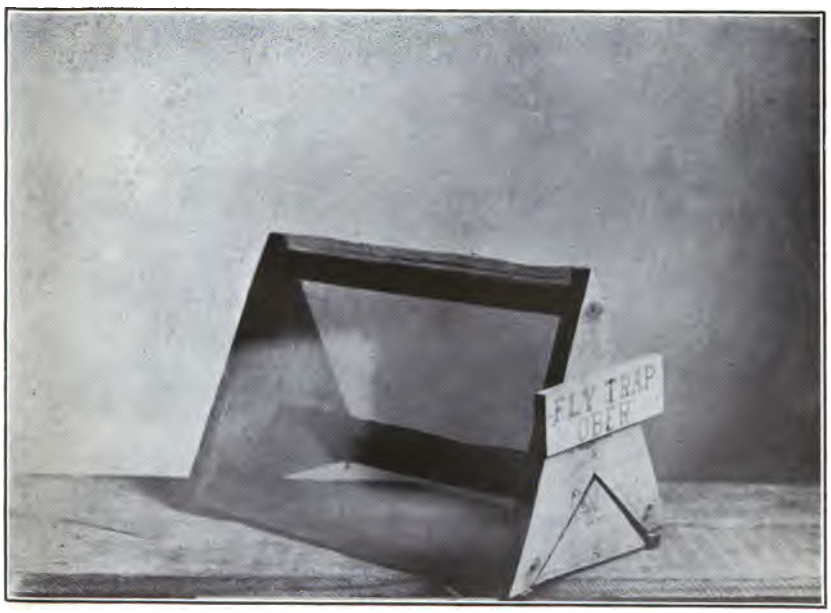
This fly trap is in no sense new in principle, since it is substantially identical with some of the commercial forms. It is, however, in our judgment, by far the most readily constructed of any of them and the method of construction is such as to require practically no tools other than a saw and a hammer. Two boards of equal width, best 11 or 12 inches, are laid off into triangles. Each pair of triangles form the ends of a trap and these ends are connected by three sticks of wood of any desired length. The usual way is to cut them of such a length that the wire screening that is available will just reach. If 36-inch screening is used it may be cut in two and an 18-inch trap be thus made. A small triangle is cut out of the base of each of the ends as shown in the drawing. Beginning at the base, the netting is tacked onto the top of this smaller triangle, then onto the outer side of the base and around over the top of the trap and down to the starting point. One of the smaller triangles is nailed back on again, after the wire is tacked onto it. The other triangle is not nailed, but is held in place by two small wood or iron buttons. At the angle formed by the apex of the small triangle small holes are made by pushing a lead pencil through the screen at intervals of about 1 inch. A nail or screw is placed at each corner of the base so as to raise the trap a quarter or three-eighths inch off the ground. The bait is placed under the trap and the fly, when it finishes feeding, crawls up through the openings into the trap. Nothing can be simpler than the construction of this little trap, it being far easier to build than a box-shaped trap and requiring much less lumber. Its efficiency is not different from any other trap of similar size.

The ease of building is seen when it is stated that several hundred of these were built with ordinary fatigue details in a very few days at the Fort Riley laboratory. To remove the flies all that is necessary to do is to turn the two buttons holding the loose triangle in place, to depress this latter slightly and, on raising the other end of the trap, the flies slide right out, being directed to the opening by the screen wire. It can be emptied in a very few seconds with very much less trouble than any other trap which we have seen.

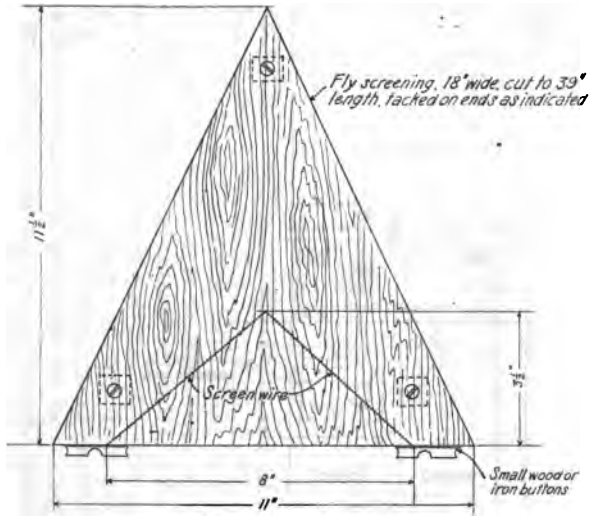
THE BALFOUR FLY KITCHEN.

This device, originating with Balfour of the British service, we have used and tested out very thoroughly at Fort Riley. While we can not recommend it as taking the place of the ordinary smaller

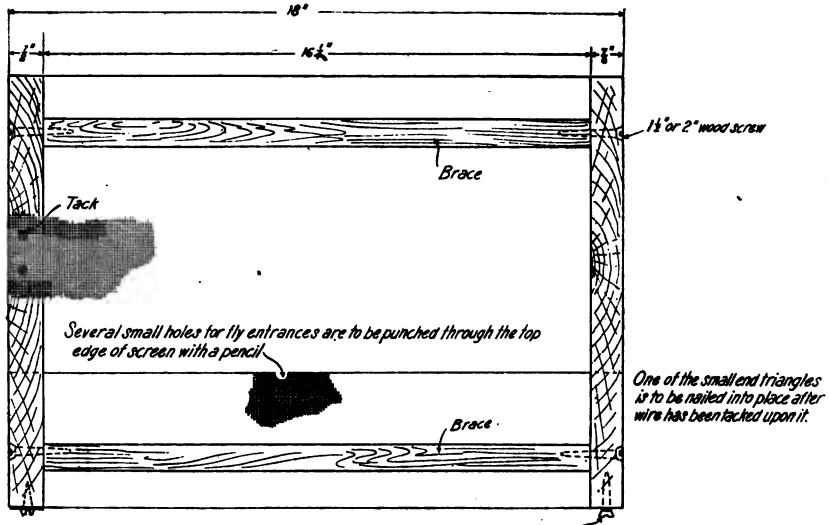
ROCK-PILE CROSS INCINERATOR.



OBER FLYTRAP.



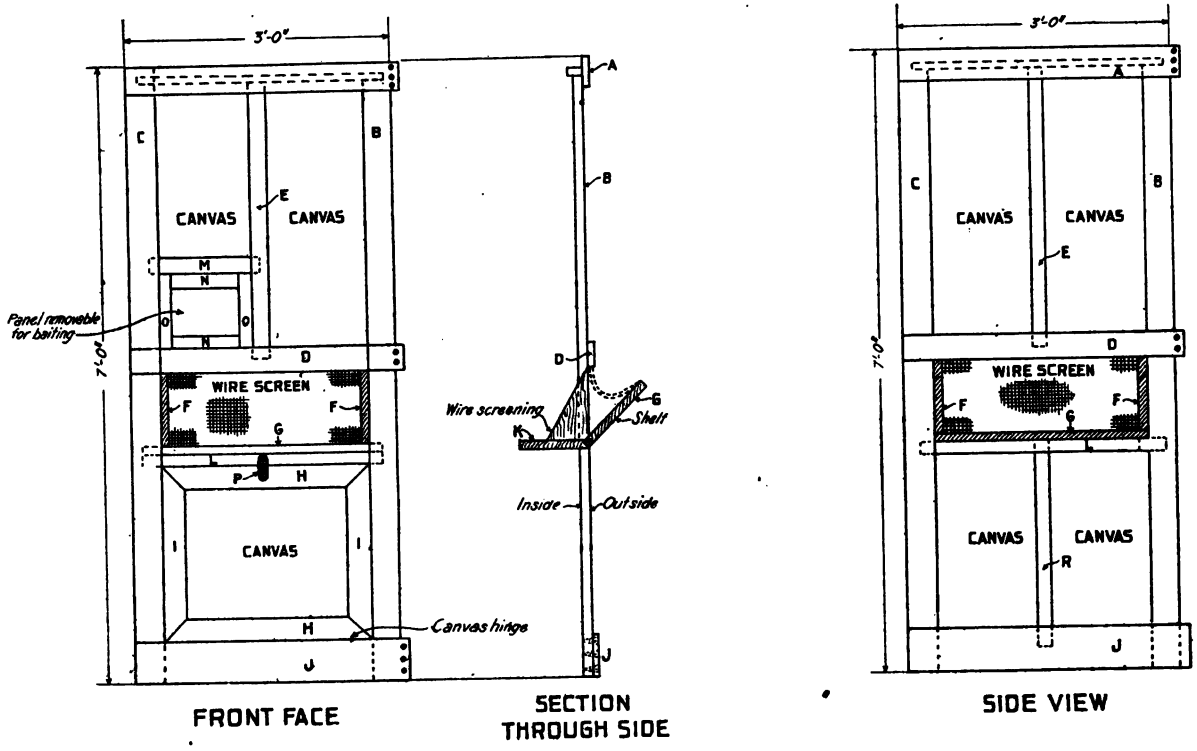
END VIEW



SIDE ELEVATION

SCALE

OBER FLY TRAP



BALFOUR FLY TRAP

flytraps, it has one distinct advantage over them which makes its use, in properly selected places and at proper times, very desirable. Balfour devised this fly room or fly kitchen because he had observed that in the kitchens flies congregated, particularly in the cold weather, and that apparently it was the heat which attracted them. As a result he devised an imitation kitchen. These are of three sizes, of which the one here described is the medium size, which is most generally available. It is nothing more nor less than a very large flytrap with a glass top. In appearance it is much like a telephone booth, the sides being made of a light frame covered with canvas and the trap portion being placed in the side horizontally in the form of long slits with wire gauze. The outstanding feature of the trap is the fact that the top is made of a window sash with glass panes so that the entire apparatus functionates after the manner of a hothouse or forcing bed. It is very important that this fact be borne in mind, since in our judgment the principal value is in the early spring months when the days are hot and the nights cold. This is the time of year at which, in the latitude of our Central States, the bluebottle fly puts in his first appearance, before the ordinary musca domestica appears. At this time such a trap does great execution, since the flies on cold days will make for it because of its warmth and stay in the trap as long as they are supplied with food and water. The details of the trap require no especial explanation. We have made it with the sides screwed together so that, if necessary, it can be transported. It can be made of the roughest of lumber and old canvas or cloth. Particular care should be given to see that the size of the slit through which the fly enters is exactly right. We have made it a little over a quarter of an inch to accommodate the larger-sized bluebottle. Later on in the year the slit may be narrowed up slightly when the ordinary house fly makes its appearance. We have, in accord with Balfour, simplified the slit and believe there is no sacrifice in efficiency in so doing. It is important that the fly kitchen be kept well baited and that fluid be furnished them, otherwise the fly will tend to find his way out. In hot weather the trap is nearly worthless, or, at least, is very much inferior to the ordinary trap, since the great heat, instead of attracting the fly, repels him and he is more likely to seek a shady, cool place than to seek additional heat.

HODGE WINDOW SASH FLYTRAP.

This very ingenious apparatus which, despite its very decided merits, seems to be very little known, makes use of the principle that in a dark room the fly seeks the light. The trap is simplicity itself. A light frame is made to fit the lower half of the window and held in place by the sash coming down on it, or, in the case of sliding windows, by the window frame abutting against it on the side. This frame is covered on the outside by a wire netting. On the inner side of the frame netting is arranged, as shown in the cross section, so that we have, in reality, a series of traps placed one above the other. Along the apex of each pyramid holes are made by separating the wires with a lead pencil or similar implement and, through these, the fly crawls. It will be seen that the principle of this trap is precisely the same

as that of the Ober or any of the commercial forms, except that the fly enters the trap in seeking the light and not because of a bait. To use it the other windows in the room should be darkened. This trap has one advantage, namely, that it catches the fly and does not merely serve to empty the room of them, as in some of the commercial types. In large rooms, with high ceilings, where swatting is difficult, these traps have been found exceedingly satisfactory. The absence of a bait is a great convenience.

Another form of the same device is to arrange the netting in such a way that a second series of folds, forming the traps, is arranged from the outside inward. At first sight it would seem that if the fly goes into the trap from the inside, because of seeking the light, he would certainly not go in the opposite direction, and, ordinarily, this is the case. On the other hand, in places where the mornings and evenings are very cool, the fly is attracted from the outside to the kitchen or mess hall because of the warmth and this arrangement catches him coming or going. A little opening in the side of the frame serves to remove the flies. It is not desirable to remove them every day, since the presence of a certain number of live flies in the trap seems to act as an attraction for more.

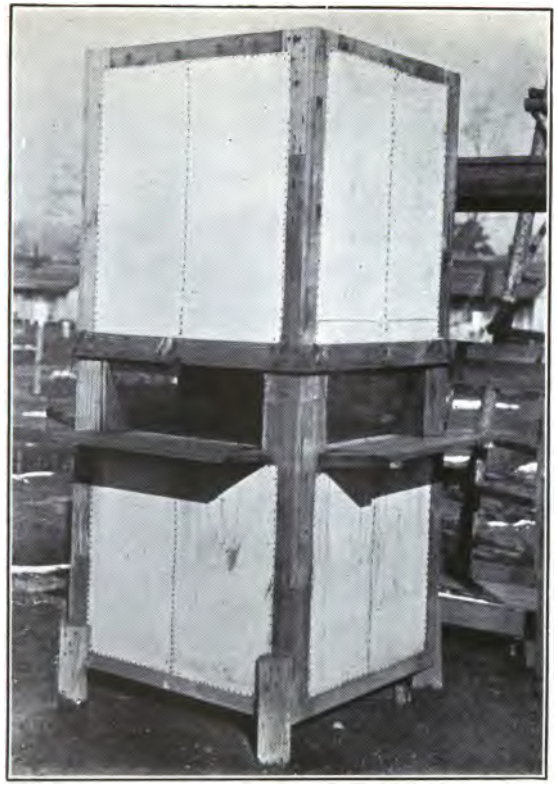
FLY BAITS.

At Camp Greenleaf during the summer of 1918 a three weeks' test was conducted with the Ober fly trap in an effort to find a really efficient bait. It was considered that such a bait should be (1) cheap, (2) always and everywhere available, (3) of such a nature as not to constitute a nuisance. A very careful count was made and kept of the flies. In addition to the house fly, a separate count was made of blue bottles and horse flies. All other insects were counted together, but they were so few in number as to be a negligible quantity and will not be mentioned further. When any particular bait seemed to be very attractive it was carried on through the entire test. The baits used were as follows:

1. Beef liver, in cans, with perforated tops.
2. Mashed cheese and molasses.
3. Sweet corn, in cans, with perforated tops.
4. Fermented canned corn.
5. Molasses, water, and vinegar.
6. Milk, water, and bread.
7. Bevo, water, and bread.
8. Ripe bananas, split longitudinally.
9. Garbage, fermented with yeast.
10. Fermented canned plums.
11. Canned salmon, in cans, with perforated tops.
12. Over-ripe banana and milk.
13. Fish heads and fish scraps.
14. Bran mixture No. 1.—Bran 3 pounds, cornstarch 1½ pounds, sugar 3 pounds, yeast 4 cakes. water to 5 gallons.
15. Bran mixture No. 2.—Bran 2 pounds, corn meal 1 pound, sirup ¾ pound, water 3 pints.

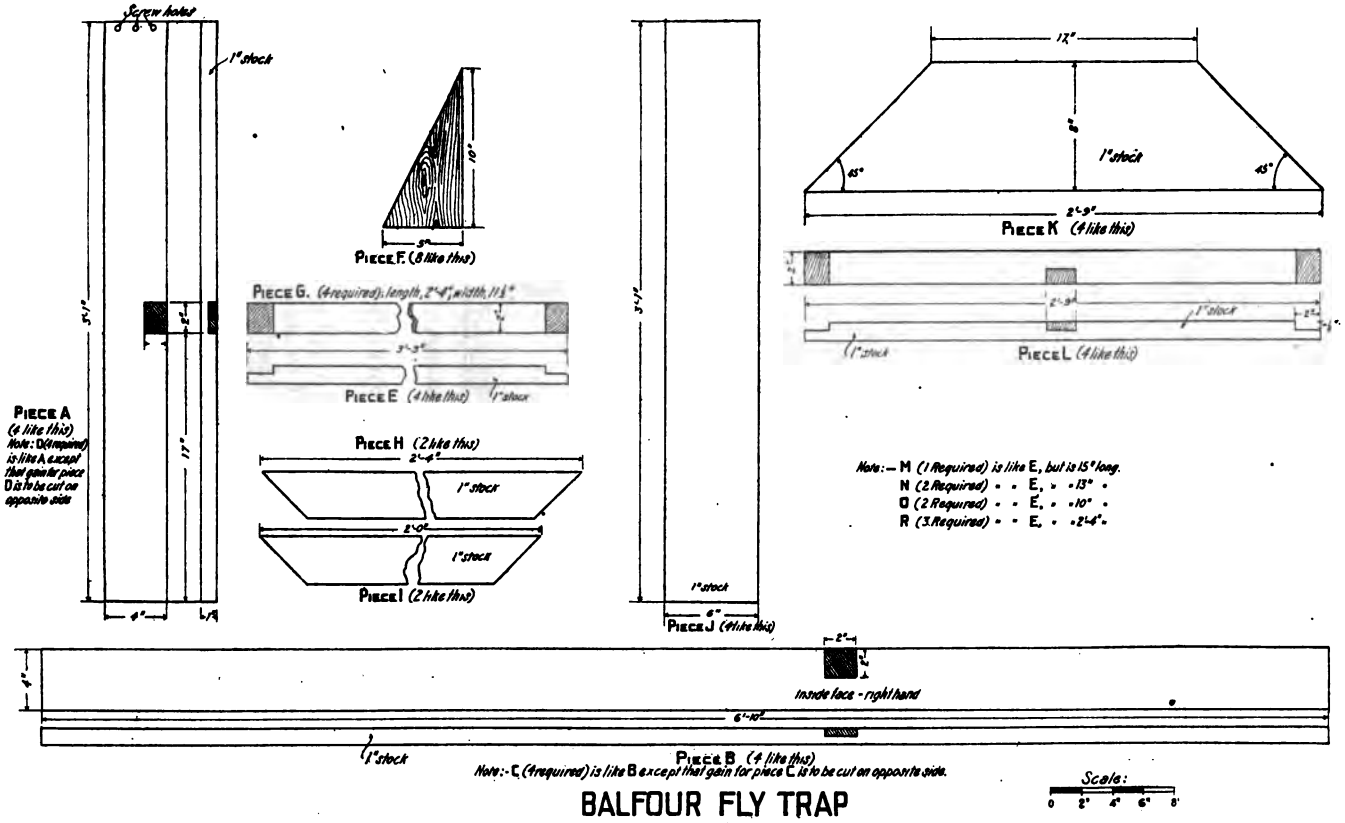
NOTE.—The bran mixtures were allowed to ferment before use.

The total number of flies caught was 43,005. Of these, 35,642, or 82.88 per cent, were house flies. The blue bottles numbered 4,444, or 10.33 per cent, and the horse flies 1,732, or 4.03 per cent.

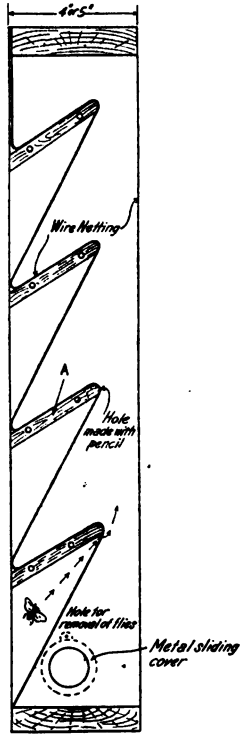


BALFOUR FLYTRAP.

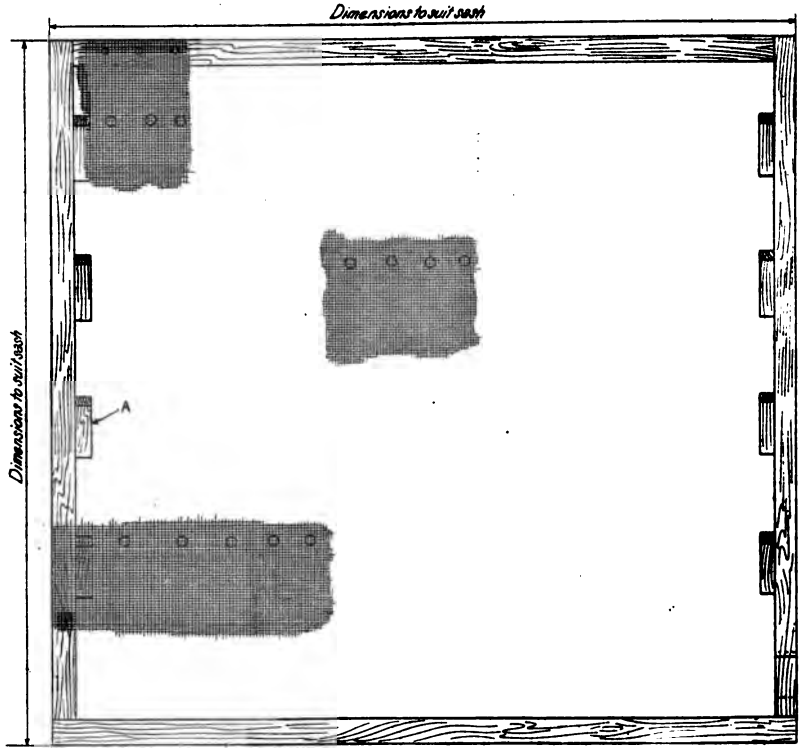
HODGE WINDOW SASH FLYTRAP.



BALFOUR FLY TRAP



TRANSVERSE SECTION



FRONT OR OUTSIDE VIEW

HODGE WINDOW FLY TRAP

The baits in the order of their efficiency and in their catches were as follows:

	Per cent of total catch.
Fish heads and fish scraps	21.34
Over-ripe banana and milk	21.30
Bran mixture No. 2	20.72
Canned salmon, perforated top	14.95
Fermented canned plums	7.52
Bran mixture No. 1	5.29
Garbage fermented with yeast	2.25
Ripe bananas split longitudinally	1.83
Bevo, water, and bread	1.58
Milk, water, and bread	1.26
Molasses, water, and vinegar	.99
Fermented canned corn	.63
Sweet corn, in cans	.13
Mashed cheese and molasses	.10
Beef liver, in cans	.05

It is thus seen that, of the 15 different baits used, only four seemed to be really efficient, namely:

1. Fish heads and fish scraps.
2. Overripe banana with sour milk.
3. Bran mixture No. 2.—Bran 2 pounds, corn meal 1 pound, sirup three-fourths pound, water 3 pints.
4. Salmon, in cans, with perforated top.

All of these baits fulfill requirements Nos. 1 and 2 of an efficient bait, but the fish baits fall down on the third requirement, viz, that the bait used shall not constitute a nuisance. The older the fish baits got and the more abhorrent the odor the more efficient they seemed to be.

The four most efficient baits included two of the putrefactive and two of the fermentative type. The odor given off by the latter is pleasant rather than otherwise. While the percentages given have all referred to the house fly, it may be stated that the two fermented baits were the most efficient as far as the blue bottle and horse flies were concerned.

It seems to be necessary for a bait to have either a fermentative or putrefactive odor to be efficient.

TANGLE-FOOT FLY WIRES.

This is a device which we believe to be much more useful than many now in use and which seems to be very little known. We have experimented with them principally in horse sheds. They are made of heavy wire twisted rather tightly. Inasmuch as a considerable number of these have to be made it is worth while to note an easy and convenient method of twisting. If the wires are to be 3 feet long when finished two posts are put in the ground, a little over 6 feet apart and into the top of each of these posts two nails are driven and the heads cut off. The wire is now strung around the nails in these posts and the ends twisted together. They should be strung very loosely. A thin stick is now used to twist up the wires from the middle. This can be done very rapidly until the desired degree of twisting has been accomplished. The wire is then cut in the middle and two rods are thus formed, each with a triangular loop on the end where the nails are placed. If the wire is not heavy, more strands can be used in the

same way, all being twisted at the same time. These rods are now coated with a sticky fly mixture of any approved type. Because of our inability to procure castor oil, which is perhaps best for this purpose, we have used a mixture of linseed oil, rosin, and acacia in the following proportions: Rosin, powdered, 10 parts; linseed oil, raw, 8 parts; acacia, powdered, 1 part; by weight. Bring the rosin and oil to a boil, separately. Mix and boil together for 15 minutes, then add the acacia slowly, being careful not to let mixture boil over. Allow to cool and coat the wires with a brush.

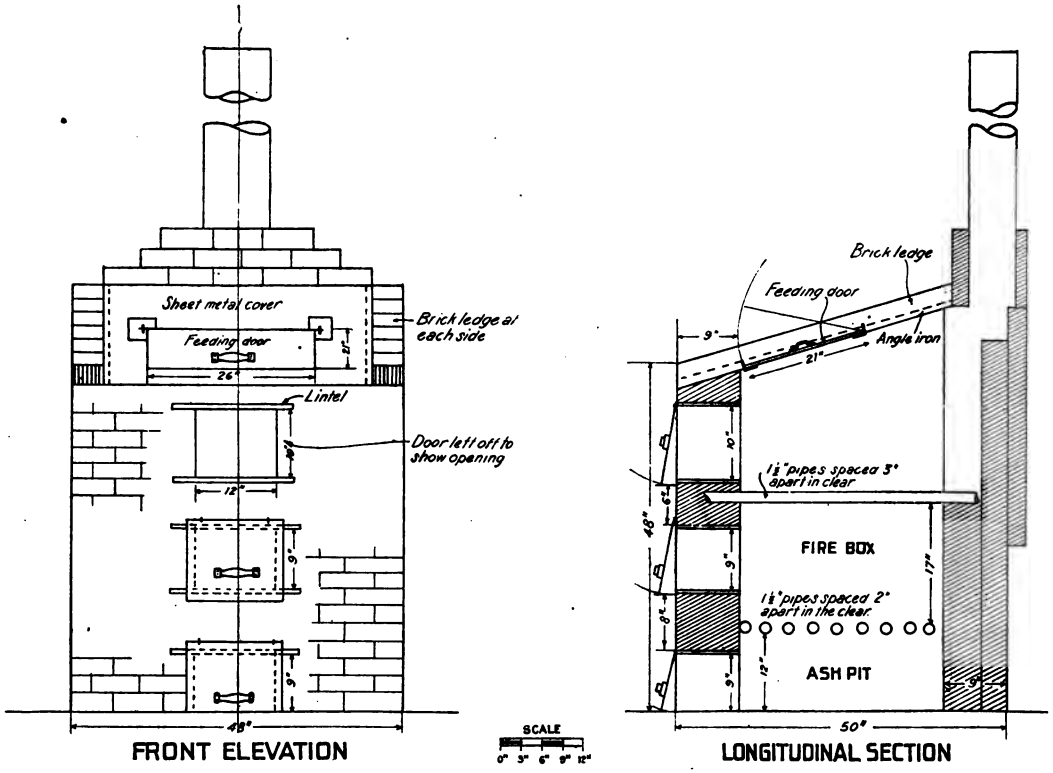
When available, old telegraph wire is the best, especially if rusty, since this causes the tanglefoot mixture to adhere more readily. Baling wire may be used, but it requires six or eight strands to give sufficient rigidity. It is not desirable to burn off the flies and sticky mixture as we have seen recommended. All that is needed is to take a piece of burlap and wipe off the flies, leaving most of the sticky mixture intact. A very light coat then suffices and the wires improve with age. The efficiency of these wires in horse sheds is quite remarkable. We have hung two in each stall high up above the horses' heads and caught an average of 96 flies per day per wire for a number of days hand running. The wires, of course, should be hung vertically, since either horizontal or oblique placing of them is much less effective. Our method of procedure was to have a man go around with a piece of burlap and a small can of the mixture and in a few hours' time he could recoat all of the wires. We have not found these wires as satisfactory mess halls unless a little cup is hung under them to prevent any possible dripping. In sheds, this is of no moment.

TRASH BURNER.

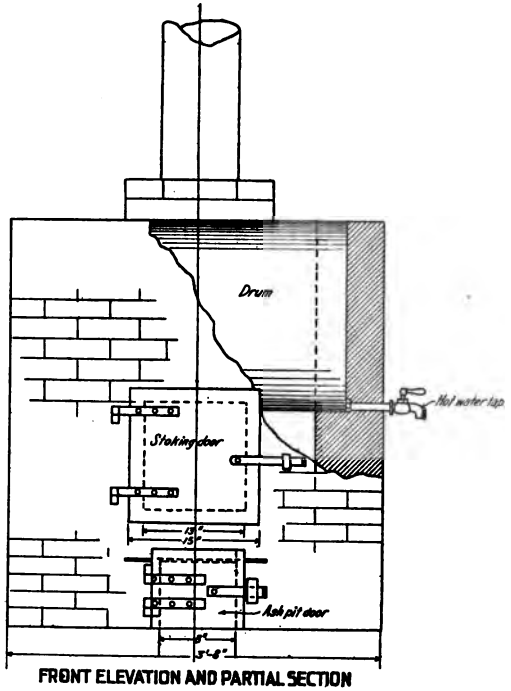
Around most hospitals and camps there is a considerable amount of combustible material to be destroyed, and in our American camps, at least, a goodly number of tin cans. These latter are frequently salvaged, but, in many places, this salvage arrangement falls down and the tin cans are then required to be burned out before being flattened and buried. The ordinary open incinerator of any type is difficult to keep well policed, is always unsighly, operates badly in rain and wind and consumes a relatively large amount of fuel. We have experimented with a closed incinerator, which shall obviate these defects. This one figured is substantially identical with the British type of incinerator with a manure-drying grid, figured in the A. E. F. manual, and which has a hot-water back. This latter is of small value in cantonments where better arrangements can be had. We have added a second grate, on which the tin cans can be placed, since they do not need to be subjected to great heat. This grate must be made of heavy pipe, preferably with a lighter pipe inside to prevent sagging and regarded as a simple box oven with a drying grate and intended to be made of small size only. This device should, in our judgment, be built around hospitals instead of the ordinary open incinerators. It is much more sightly, much more efficient, can be kept well policed, obviates any fire danger, and is in every way preferable. Its cost is inconsiderable, it can be readily put up with unskilled labor and if not abused, or run beyond its capacity, will last indefinitely.

A. E. F. MANURE BURNER MODIFIED TO SERVE AS A TRASH BURNER.

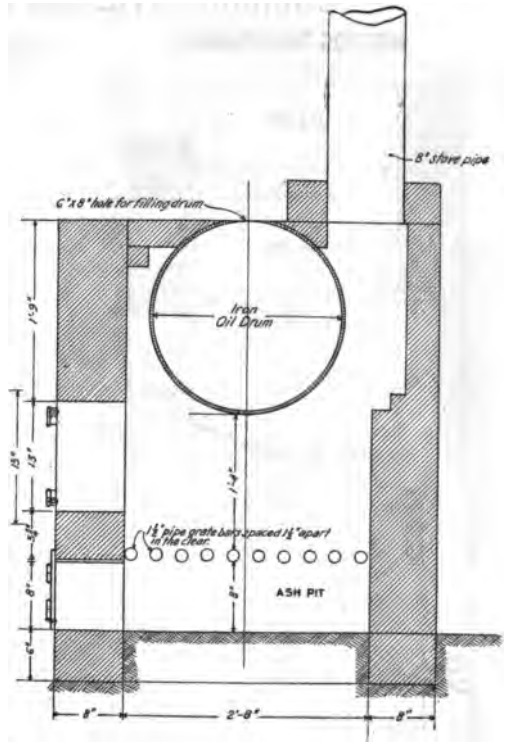
MOXEY WATER HEATER AND INCINERATOR.



MANURE BURNER MODIFIED FOR TRASH BURNING

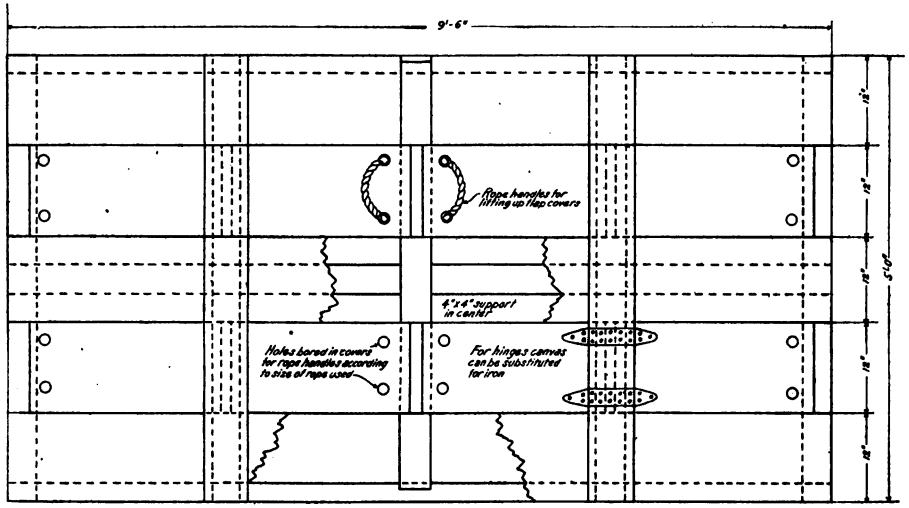


FRONT ELEVATION AND PARTIAL SECTION



MOXEY INCINERATOR AND WATER HEATER

Scale:



LUCAS SQUAT LATRINE COVER

THE MOXEY INCINERATOR AND WATER HEATER.

We have found this device, which has been used in the British service, very useful where there is much combustible trash to be burned and, at the same time, it is desired to have a moderate amount of hot water. It consists merely of an oil drum placed with its long axis horizontal and with a convenient-sized opening cut in the side and placed uppermost. Through this opening the water is put in. A box-shaped brick oven, provided with a grate, is made of the proper size to just take this drum. A pipe is run through the wall on one side and is screwed into the opening by removing the plug. This may be provided with a stop cock, or a simple wooden plug, which answers every purpose. While this heater can, in no sense, be called a really efficient water heater, it answers admirably for a small organization where nothing better is available.

LUCAS SQUAT LATRINE COVER.

While primarily designed to be used as a cover for a simple straddle trench, this device is, in our opinion, worthy of a much more extended use. The straddle trench is, in the very nature of things, designed to be used as a mere temporary expedient, for two or three days' use. The latrine cover makes the straddle trench fly proof; but this can be more simply done by covering in with a couple of inches of earth. The straddle trench, as ordinarily made, can be used only for two or three days. It is questionable, therefore, whether any latrine cover for a straddle trench is worth while.

On the other hand, by arranging a double latrine cover, each with four holes, making eight holes in all, as shown in our construction, we have virtually a latrine box without the cumbersome sides and heavy framework, which subserves every purpose of a standard latrine box, using, however, the squatting position. It is indeed a squat latrine and this is in reality the best name for it. We have used one for several months for the personnel in our field laboratory and found that it operated to our entire satisfaction. The size of the pit is about the same, indeed even a little wider than the usual latrine pit and it may be dug to any depth. It may be treated with oil or burned out in exactly the same way as any other latrine. Using this cover, in connection with the method of fly proofing by means of oiled sacking, we have in reality a very nearly ideal form of latrine. One practical point we have found to be of great importance. All such latrine covers warp very badly when exposed to sun and rain and we have found that this can be almost entirely prevented by a thorough soaking with oil on all surfaces and edges before using. A couple of coats of oil put on and rubbed in thoroughly will keep the covers in excellent condition, even when exposed to sun and rain.

The method of fastening the seat stops should be especially noted. Two uprights and a cross piece on top are placed upright and held in place by two twisted wires, as shown in the illustration. These wires can be cut or, better, unfastened and the stops taken down and packed inside the frame so that the whole latrine cover packs in a flat package.

INCINERATORS.

Company rock-pile incinerators.—These are merely shallow depressions in the ground, of various shapes, lined with rock or with a low rock wall in addition. The principal ones are the horseshoe and the Straub, both of which are too well known to need any description. There is a common idea that a large amount of sullage water can be evaporated by pouring it upon the rocks after these have become heated. Careful observation has shown us that most of the water supposed to be evaporated in reality sinks into the ground, if this be sufficiently absorbent. It is our judgment that these rock-pile incinerators can only be regarded as the merest makeshifts and should be abandoned for cantonments or permanent camps where materials are available for the construction of better types. We say this advisedly because our studies lead us to the conclusion that it would be far cheaper to build better incinerators than to consume the very large amount of fuel required for the operation of these.

Larger incinerators of the same type are the Havard and the so-called quartermaster type. The above remarks are equally applicable to these.

Semiclosed incinerators with rock or brick walls.—We have constructed a considerable number of these and there is very little to choose between them. All of them consist essentially of low walls and the best of them have an improvised grate. One important point, which is frequently neglected, is that the diameter should not be too large in proportion to the height and should generally be less than the height. Some of the principal ones are:

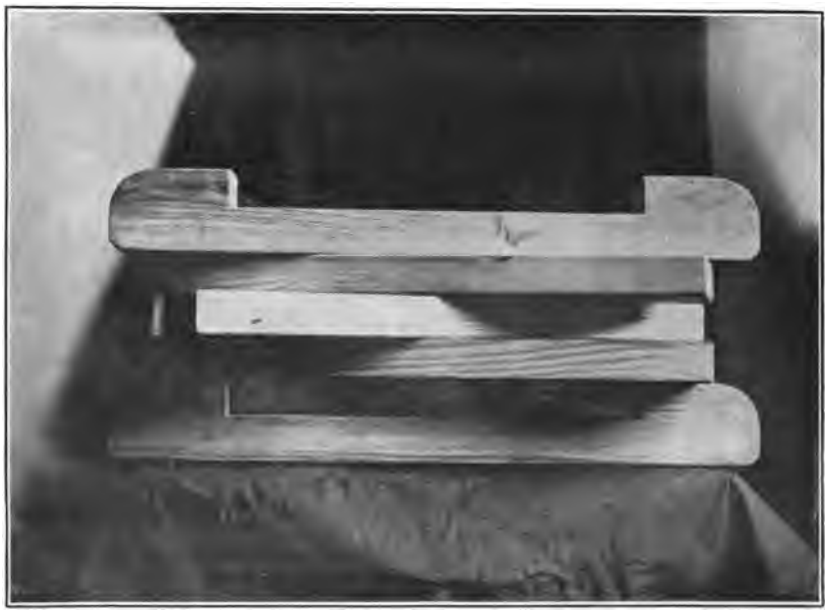
Richardson incinerator.—This is a circular rock wall about 5½ or 6 feet in diameter and approximately the same height. It has four openings to remove the ashes and to secure proper draft and, above these, is a grate made by laying pipe, resting on a central stone pier and embedded at the outer end in the wall itself. Such an incinerator will take care of the solid garbage of a regiment, but the fuel consumption is very considerable.

Guthrie incinerator and evaporator.—This was originally designed for the evaporation of sullage water where this could not be disposed of satisfactorily in any other way. This is a very expensive and unsatisfactory method of handling liquid garbage and should be replaced whenever possible by the use of suitable grease traps. A large number of these incinerators are in use for burning solid garbage, for which purpose they are but illy adapted. In some places they are being used with buckets on top for heating water for mess kits. Used in this way they are very extravagant of fuel and should be replaced by some of the better types of water heaters.

Caldwell incinerator.—The Caldwell incinerator, which consists of clay or sod or even cement plastered over a barrel arranged over cross trenches, is too well known and too widely used to need any especial description. It consumes about the same amount of fuel as the other incinerators of the semiclosed types.

The fuel consumption of these incinerators runs from 1 pound of wood to 2 pounds of wood for each pound of garbage consumed, so that the wood consumption alone in a cantonment where incinerators of this type are used for the purpose of consuming garbage is appallingly great.

LUCAS SQUAT LATRINE COVER.



KNOCKDOWN MEAT BLOCK (LOOSE ENDS) DISASSEMBLED.

Simple closed incinerators with grate (box type).—The number of such incinerators is legion and it will subserve no useful purpose to describe more than two or three of these. They are of al sizes and shapes and may be used for incineration of combustible refuse, garbage, manure, or human feces. Essentially they all consist of a stone or brick oven with a suitable fire door, ash door, and a grate. The better types have a single shelf or drying grate upon which the wet material is placed until it is dried out sufficiently to be raked down upon the fire bars below. These incinerators are a distinct improvement over the semiclosed types because of their greater economy in fuel and because they will not be put out by heavy rains. For this reason they should be preferred whenever the materials are at hand to construct them. The simpler the construction the better and a simple box, such as a Moxey (q. v.), with or without the water drums, is perhaps as efficient as any.

Feces destructor, British type (Pike).—This is a simple closed box with a drying shelf which has the opening for the flue beneath the shelf, the idea being that the odors from the dried material will pass through the hot flame and be destroyed. Our experiments with this apparatus have not been satisfactory. With the lid down it draws very indifferently and when the lid is raised flames pour out of the openings in such a way as to make it difficult to charge the furnace. It possesses, in our judgment, no especial advantages over the ordinary forms.

Trinca incinerator.—This is a beehive shaped arrangement arranged with chutes for the introduction of the feces. It has one feature which, to our mind, absolutely condemns it, and that is that when the shelf burns out, or in any way gets out of order, there is no way of fixing it without dismantling the apparatus.

The Charles (Alamo) incinerator.—This is a form devised in our own service and has a fishhook shape. It is made on a gradual inclined plane. Its fuel consumption is very great, at least twice that of the other incinerators of this group. It is difficult to build and has little to recommend it.

The Thayer incinerator.—This is a closed apparatus, with two chambers, made of large caliber water pipe. As an improvised apparatus it is ingenious, but should not be built as a matter of choice.

The Palmer and Kinnard incinerators.—These are two types which are unimportant modifications of the Guthrie. What is applicable to the Guthrie is applicable to these.

Incinerators of the incline plane type.—Two of these are described and figured by Lelean. They are to be regarded merely as improvisations.

MANURE INCINERATORS.

Panama incinerator.—This was described by Lewis and Miller and is too well known to need elaborate description. In our construction we have used clamps to hold the rails together, which make it a little easier to build. Our experience is that this incinerator acts admirably in dry weather and where there is a prevailing wind, but that its capacity is not great enough to make it very efficient in taking care of such an organization as a remount station or a division.

The high rock wall incinerator (Canadian type).—This has been discussed under the description of the Schmalhorst incinerator.

The circular rock manure incinerator.—This is merely a large rock incinerator with a low circular wall about 3 feet high or less and paved with a layer of flat rock on top of large round ones. There are four draft openings on the sides. This apparatus functionates well for a short time, but the ashes seem to fill up the interstices between the round rocks and has to be rebuilt frequently. It can only be considered as an improvisation.

Closed manure incinerator with grate (British type).—This is a small box oven with grate. It burns manure satisfactorily, but in such small quantities as to be of very little use.

WATER HEATERS.

The laboratory has done a good deal of experimentation with the different types of water heaters, both improvised and specially built. Of the improvised types by far the most economical in fuel consumption is the type described by the American Expeditionary Forces, consisting of a galvanized-iron can, with a suitable sized small tub, arranged for the water receptacle. Throughout this camp and some others the Guthrie incinerator is made use of as a water heater by placing buckets of water, supported on a piece of sheet iron, over the fire. The large size of the fire box and the small heating area make this a very costly and inefficient method and the capacity is so small that it should never be put up where material is available to build something better, since the expense of operation alone is sufficient to condemn it.

Guthrie water heater.—This is an ordinary Guthrie incinerator arranged with a series of three or four coils emptying into a barrel. It is very expensive in fuel and has an inconsiderable capacity. The cost of building one is very nearly as great as that required to build a multiple shelf (q. v.), which has a great many times the capacity and a much smaller consumption of fuel.

Saville water heater.—This well-known apparatus consists essentially of a Guthrie incinerator, with long coils of pipe inside and connected with a boiler. It is a very much better apparatus than any of the others in ordinary use, but its fuel consumption is quite great and the capacity is small.

LATRINES AND FECES SEPARATORS.

The experience of the present war has seemed quite definitely to tend toward incineration of the feces. This makes it imperative to separate the urine from the feces, since the latter has not sufficient heat units to evaporate the former without the use of large quantities of fuel. Two original forms of feces separators have been already described (q. v.).

Baruch urine and feces separator.—Baruch has described two types, a semistationary and a portable one. The former was referred to the laboratory for study and criticism. A thorough trial was given and the remarks may be found in Baruch's article, Military Surgeon, July, 1918. The portable type is efficient and the one objection which

can be made to it is that it seems somewhat more complicated than necessary.

Front-line latrines—Fly-proof seat for pail system.—A number of these have been constructed. They are fully described in Lelean.

The Reddy latrine seat.—This is a portable latrine seat which has for its purpose the doing away with the sides of the box. It has only two holes and is placed on the ground over a small-sized latrine pit. Along one side is dug a small pit sufficiently deep and wide to accommodate the feet and this foot trench is connected with the main pit by a small pipe to allow water to drain into it. It answers well in hard, firm, clay ground, which will not cave in readily, but is inferior to the squat latrine.

American oil pit.—This name is given by the French authors to a pit covered in with a framework, having in it a trapdoor and used for the disposal of feces, these being sprinkled daily with oil. It is virtually a large square latrine pit without seats. It should be fly proof and should be made of sufficiently large size to accommodate the feces of the command for one or two months at least. In suitable ground, where the ground water does not interfere, it may be as much as 12 or 14 feet deep, though such a depth is not often necessary. Where there is danger of the ground caving in, the sides should be revetted, which is best done with saplings and twigs. Sand bags should only be used as the last resource.

Urinal and soakage trenches (can type).—This consists of a series of shallow trenches radiating, fan-shaped, from a common point, over which is placed a galvanized-iron can with perforations in the bottom. The trenches are filled with rock and fly proofed with oil sacking. The urine, which is emptied into the can, seeps out gradually into the trenches, where it is slowly absorbed. The device is most useful where the ground water is so high as to make a deeper soakage pit impracticable.

Urine soakage pit.—Described fully in Lelean. It should be particularly noted that even in the most unpromising clayey soils, where it would seem impossible to have any absorption, one can frequently find pockets of sand, sometimes of considerable size, where such a soakage pit works admirably. At Fort Riley, where the ground was nearly pure clay, we succeeded in finding such pockets and had five such pits, used by several thousand men, in operation for several months with the greatest satisfaction.

Company sink.—This is the old-fashioned company sink, open, unsanitary and to be absolutely condemned.

The Lumsden-Roberts-Stiles sanitary privy (public health type).—This is the well-known type developed by the Public Health Service and constructed in larger and smaller forms. It is described in Havard and a very instructive special pamphlet was gotten out by the Kentucky state board of health. This system is referred to frequently as the Kentucky sanitary privy and has been used so widely as to need no comment.

Deep trench, fly-proof latrine.—We have found most generally serviceable the latrine box described by Lelean, using a slightly more substantial construction. The method of fly-proofing by oiled sacking is to be highly commended.

McPherson improved latrine.—This is a crude form of urine and feces separator made by cutting biscuit tins in two, using one for urine; the other, which is covered with a sheet of paper, straw, or grass, is used for the feces. A soakage pit close at hand disposes of the urine and the feces are burned in small portable incinerators by each individual as he uses the latrine. McPherson reports, J. R., A. M. C., that the results obtained in the division in which this device was used were excellent. Probably much depends upon good discipline.

GREASE TRAPS.

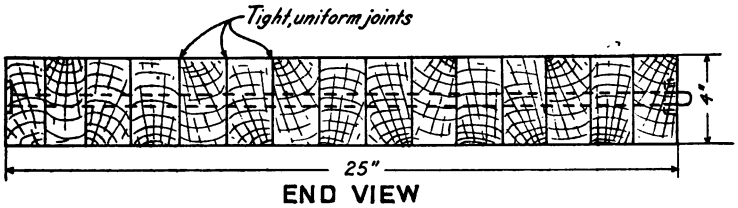
The number of grease traps which have been devised have been very great and this is perhaps the very best evidence that none of them are satisfactory. We have made a very intensive study of the subject and have come to the following conclusions: The most important point in any grease trap is that there should be a preliminary period of standing. For this purpose the grease trap should hold at least 48 hours' output, since it requires about this length of time for the grease to rise to the surface and be skimmed off. The scum which rises to the surface contained 14.3 per cent of fat on analysis. A period of standing less than this is inadequate under average conditions and a longer period serves no useful purpose. It is impossible to remove all the grease by this method alone, since the soaps remain, in considerable part, in solution and there is always a small amount of free fat which does not rise to the surface. We have had numerous analyses made and this has been invariably the case, no matter which type of appliance we have used. A considerable portion of the remainder can be removed by sand filtration, but even then the effluent cannot be regarded as absolutely perfect, although it is comparatively inoffensive. The serious drawback to sand filtration is that it works so slowly, when really efficient, as to make the capacity very small. We feel that all of the grease traps and filters are unsatisfactory and there is abundant opportunity for more research along this line.

Montgomery grease trap.—This is substantially a large box arranged with a considerable number of baffle plates and filled with sand and gravel. We have constructed it according to the original blue prints and, while it gives a fairly good effluent, it is so cumbersome and difficult to clean, at least in this form, that it is not likely to prove very useful excepting under special conditions.

Improvised barrel grease trap.—This consists of a barrel filled with 2 or 3 inches of fine gravel on top of which a diaphragm, made of a gunny sack filled with about an inch and a half of fine sand and closed, is placed in such a way that the pancakelike diaphragm fits tightly against the sides of the barrel. On top of this is placed 2 or 3 inches of sand. The purpose of this diaphragm is to keep the sand from washing out through the opening in the side of the barrel just above the bottom. The great difficulty in filtering dishwater through the sand and gravel is that the sand is washed out through the opening and the dishwater thus escapes filtering. The diaphragm obviates this completely. This device, by varying the depth of the layer of sand on top of the diaphragm, gives a very good effluent. By scraping off a half inch or an inch of this top layer of sand each day the barrel works fairly satisfactorily. Its one serious drawback,

BUILT-UP MEAT BLOCK.

KNOCKDOWN MEAT BLCCK (LOOSE ENDS) ASSEMBLED.



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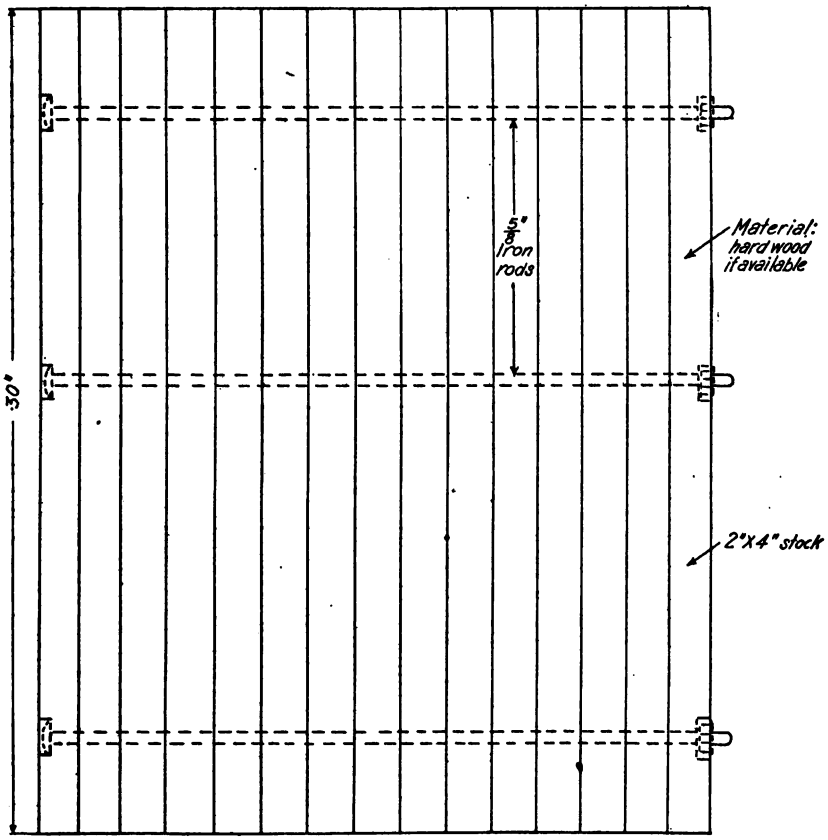
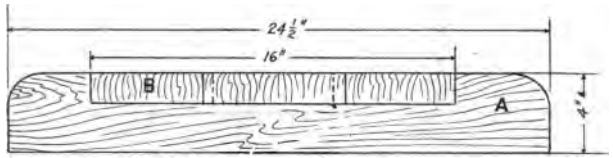


TOP VIEW

BUILT-UP MEAT BLOCK



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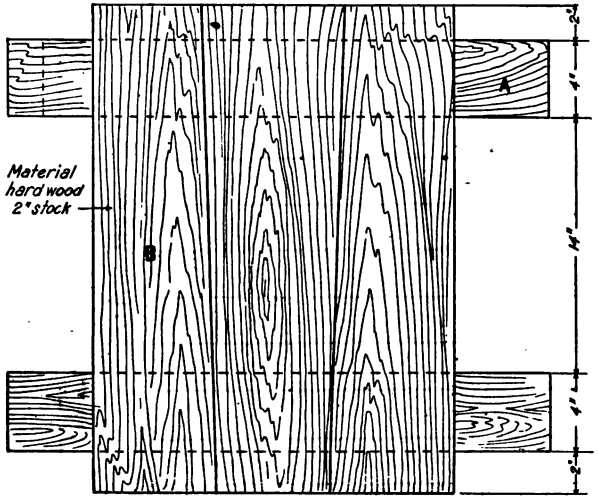

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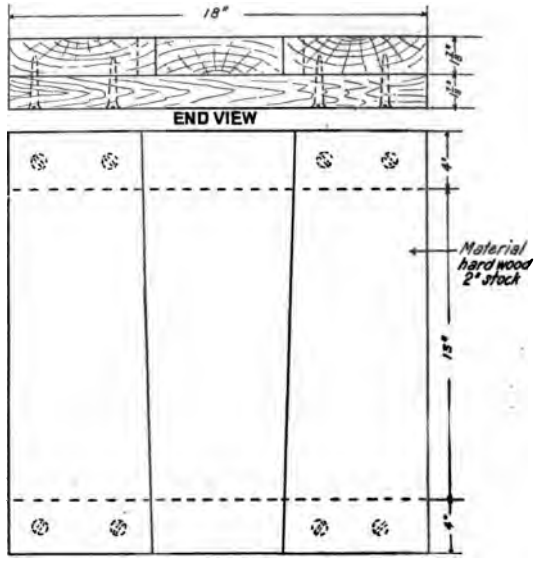
TYPE WITH LOOSE ENDS



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TOP VIEW

TYPE WITH FIXED ENDS

KNOCK-DOWN MEAT BLOCKS

which it has in common with all sand filters, is that it operates quite slowly and needs careful watching. Three or four such barrels can be placed in a battery and where the dishwater is not large in amount this answers very well. We have had the effluent analyzed, with the following result: The fat content was 0.0075 per cent. The nitrogen content was 0.010 per cent.

COOKING APPARATUS.

The laboratory has built a number of these, mostly of the simpler types, such as the open baking trough, bean pit, two-barrel mud range, two-barrel clay oven, the clay oven described by Ford and used on the border, the improvised company kitchen described by Lelean and the Dunne-Wagner. Of these the last three are by far the most efficient and there is but little choice between them. The Dunne-Wagner (q. v.) has been described in detail.

DELOUSING APPARATUS.

Of these we have built a number of the following kinds:

Serbian barrel (type 2).—This may be built of either a galvanized-iron can or a barrel. The former is the easier to build, the latter is the more efficient so far as keeping up the temperature is concerned. We have had no difficulty, with a change of blankets or overcoats, in keeping the temperature at 211° F. (99.5° C.) indefinitely. We have also built a battery, with four galvanized-iron cans, which is satisfactory.

Delousing chambers.—The delousing rooms, which have been used so extensively abroad, have also been constructed here. They need no fuller description.

MISCELLANEOUS APPARATUS.

A considerable number of pieces of apparatus for miscellaneous purposes have been constructed but, as they have been described elsewhere and are of small importance, need only to be mentioned: Underground incinerator, cross trench type (Pike); underground incinerator, oven type (Pike); improvised shower bath (Lelean); sanitary canned-goods rack (army type); suspended meat cage; improvised tepee meat cage; garbage can rack (Woolley); fly exit screen door; ablution bench (Jacobs); model storeroom; model kitchen; model latrine shelter; improvised ice boxes.

MEAT BLOCKS.

The daily experience of the sanitary inspector shows that one of the difficulties in keeping the kitchen table thoroughly clean depends on the fact that much cutting is done upon it, especially of meat, and this soon causes the surface to be badly scarred. The writer has repeatedly seen new tables rendered entirely insanitary after a few months' use. To obviate this a meat block should be furnished each kitchen, as well as a light board for cutting bread. The latter is very simple, the former requires a little more careful construction. We have experimented with a good many different types of meat

blocks and can unhesitatingly recommend the three following forms as being practical, efficient, and sanitary:

(1) **Built-up meat block.**—This is made of a number of pieces of two by fours which are almost everywhere to be had. Having determined the length of the block desired these two by fours are cut to this length in sufficient number so that, when placed with their broader surfaces together, they will give the desired width. They are then planed perfectly smooth until they fit together leaving no cracks. Holes are bored through them as shown in the drawing and, through these holes iron rods are run. These rods are provided with a head at one end which is countersunk and a screw thread and nut at the other. It makes a neat arrangement to countersink the nut as well. On tightening the rods the strips are held together with no cracks. For cutting very large pieces of meat it may be desirable to use two by sixes, held together in exactly the same way.

(2) **Knockdown meat block** (*fixed ends.*)—The ends are made of two by fours with the broad sides up and down. To these are screwed two pieces of two by six plank, tapered off slightly toward one end. The straight edges are placed so as to form the outside edge of the block and the two tapered edges are so placed that they leave a wedge-shaped opening between. A third piece of two by six is now planed to fit this opening. In use this last piece is driven lightly into the opening and taken apart each day for scrubbing. This meat block, which was used and, I believe, designed in the field hospitals at Fort Riley, has been used quite extensively by us at Greenleaf and has given great satisfaction wherever used.

(3) **Knockdown meat block** (*loose ends.*)—This is substantially identical with (2) except that the two by fours, forming the ends, are not fastened to the two by sixes forming the side pieces. It has the advantage of being entirely take-down but has the disadvantage of being slightly more complicated. If either of these are desired somewhat longer two wedges instead of one can be used in between.

LITERATURE.

There is no attempt made to indicate all of the sources to which we are indebted. In addition to the excellent manuals of Lelean, Ford, Havard, and others, the following articles gleaned from the service journals of the British Army and our own have been found most helpful and suggestive:

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MOXEY.—Combined Incinerator and Water Heater, page 385, volume 24, 1915.

SHARP.—New Latrine for Use in Camps, page 349, volume 25, 1915.

MACPHERSON.—A System of Latrine Construction for Disposal of Latrine Contents by Individual Incineration, page 398, volume 25, 1915.

MARETT.—Fly Prevention Measures, page 496, volume 25, 1915.

PIKE.—Field Sanitation (excellent discussion of a number of improvised apparatus), page 330, volume 26, 1916.

BALFOUR.—Fly Traps For Camps, Hospital Precincts, and Trench Areas, page 61, volume 27, 1916.

GOODE.—A Brief Account of the Method of Providing Baths for the British Soldier in the Field, page 363, volume 27, 1916.

SHARPE.—Ablution Water Purification, page 519, volume 27, 1916.

DAVEY.—A Simple Grease Trap for Camps, page 758, volume 27, 1916.

MACKENZIE.—A Suggested Latrine System for the Use of Troops in the Field on Line of Communication and at the Base (feces separator, etc.), page 767, volume 27, 1916.

ELLIS.—Devices for the Disposal of Waste Water in Camp, page 604, volume 28, 1917.

MARETT.—Filters and Filtration, page 206, volume 29, 1917.

NEAL.—A Simple Improvised Grease Trap, page 214, volume 29, 1917.

THE MILITARY SURGEON.

DECKER.—San Diego Maneuver Camp, page 271, volume 29, 1911.

STRAUB.—Sanitation of a Maneuver Camp at San Antonio, Texas, page 607, volume 29, 1911.

LYSTER.—Advantages of an Accepted Plan for Latrine Boxes, page 580, volume 30, 1912.

MILLER.—The Sanitation of the Second Division, U. S. Army, at Texas City and Galveston, Texas, March 1, to July 31, 1913, page 503, volume 33, 1913.

PATTERSON.—A Straddle Trench Cover, page 565, volume 32, 1913.

CHIE.—Investigations Relative to the Life Cycle, Breeding, and Some Practical Means of Reducing the Multiplication of Flies in Camp, page 132, volume 35, 1914.
OXWORTHY.—Incinerators at the San Antonio Maneuver Camp, page 447, volume 34, 1914.
AGE.—Fly Trap, page 255, August, 1917.
ILITARY OBSERVER.—Camp Sanitation in Trench Warfare, page 703, December, 1917.
BARUCH.—Disposal of Excreta in the Trenches, page 75, January, 1918.
LUCAS.—Lucas Squat Latrine, page 346, March, 1918.
YODER.—A Simple Automatic Non-Infecting Cover for a Pit Privy, page 704, June, 1918.

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